TECHNICAL REPORT

TR-RE-65-54

QUALIFICATION TEST OF SATURN S-IB STAGE LOX REPLENISHING VALVE (60C20457)

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ABSTRACT

This report contains the results of qualification tests performed on LOX Replenishing Valve 60C20457.

The valve met the qualification requirements of the procurement specification with the exception of some shaft seal leakage. This leakage was caused by a sub-standard finish on the shaft. When corrected to drawing specifications, the leakage was stopped.

The LOX Replenishing Valve 60C20457 is considered qualified for use on the Saturn S-IB stage.

TABLE OF CONTENTS

LIST OF DATA SHEETS

6

LIST OF DATA SHEETS (Continued)

LIST OF ILLUSTRATIONS

Appendix C

7

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

8

QUALIFICATION TEST

OF

SATURN S-IB STAGE

LOX REPLENISHING VALVE

(60C20457)

1 OBJECT

The purpose of this test program was to determine if LOX Replenishing Valve 60C20457 (see figure 1, appendix C) would meet the qualification requirements of specification 60C26012.

2 CONLUSIONS

LOX Replenishing Valve 60C20457 met the qualification requirements of procurement specification 60C26012 with the following exception:

> Shaft Seal Leakage. The rms finish of the shafts (both samples) failed to meet vendor drawing requirements and excessive leakage resulted. When reworked to meet or exceed the finish requirements, the leakage stopped.

It is concluded that LOX Replenishing Valve 60C20457 is qualified for use on the Saturn S-IB Stage. See table 1 for a summary of tests.

3. RECOMMENDATIONS

The following recommendations are made based upon findings of this test program:

a) The procurement specification should be amended to include a standard test configuration for determining operating time.

b) More Stringent vendor quality control should be exercised to ensure that delivered hardware conforms to the drawing and specification requirements.

4 INTRODUCTION

Qualification tests were performed in accordance with Chrysler Corporation Space Division (CCSD) Technical Procedure TP-RE-64-43, Qualification Test of Saturn S-IB Stage LOX Replenishing Valve (60C20457), as revised in appendix D.

5 DESCRIPTION OF TEST SAMPLE

5.1 Supply Source. The LOX Replenishing Valve is manufactured by the Parker Aircraft Company as their part number 2630287. A sample lot of two valves was procured for test and evaluation (serial numbers 102 and 104).

Table 1. Test Summary

	Operational Boundary	Test Results Sample No.		Remarks
		102	104	
Proof Pressure:				
Flow Chamber	225 psig	P	P	
Control Piston	1125 psig	P	P	
Functional	Functionally Operative	P	P	
Dielectric Strength	1000 V AC	P	P	
High Temperature	130°F	P	M	See 6.2.4
Humidity	Mil-E-5272C	P	X	
Salt Spray	Mil-E-5272C	M	X	See 6.2.6
Vibration	30g	P	P	
Impact Shock	50g	M	P	See 6.2.8
Life Cycle	1000 Cycles	P	P	
Burst:				
Flow Chamber	375 psig	P	P	
Control Piston	1875 psig	P	P	

Legend:
P – Passed
M – Marginal
X – Not Tested

16

5.2 Function. The LOX Replenishing Valve is a two-inch, nominal diameter, bi-directional ball valve. It weighs ten pounds and measures 7 by 8.8 by 9 inches. It is a spring loaded, normally closed (NC) valve which is opened by a pneumatic control piston assembly. A single valve is located near the bottom of LOX tank 0-4 at station 207 (see appendix E) and is used to make final weight adjustments by adding or draining LOX from the LOX tanks.

6 DISCUSSION

6.1 General. The sample valve assemblies were inspected by the Test and Evaluation Section for conformance to specification 60C26012, revision 3.

At the completion of the test program, each test sample was disassembled and inspected in order to determine its internal condition.

The internal condition of the test samples was generally good. The control piston experienced minor internal chafing from the spring and an insignificant amount of this aluminum imbedded in the top of the control piston and in the piston seals (see figure 2, appendix C). Scratch marks were also noted on the periphery of the ball (see figure 3, appendix C). From visual inspections of the test samples conducted throughout the test program, it was determined that the scratching of the ball occurred during the last 100 cycles of the life cycle test (flow chamber pressurized to 150 psig with LN_2 and flow when the gate was open).

A re-evaluation of the pressure requirements concluded that the specification requirement did not agree with the system parameters. Propulsion and Vehicle Engineering issued a specification change reducing the maximum flow chamber pressure to 90 psig during flow control gate operation.

6.2 Tests

6.2.1 Proof Pressure. Each sample valve assembly satisfactorily completed the following proof pressure tests. See figure 11, appendix C for schematic of test setup.

6.2.1.1 Flow Chamber. With the flow control gate in the fully open position, the outlet port of the flow chamber was pneumatically pressurized to 225 psig. This pressure was then held for five minutes. The flow gate was closed and the inlet port vented. The outlet port was again pneumatically pressurized to 225 psig and held for five minutes.

6.2.1.2 Control Piston. With the flow chamber vented, the control piston was pneumatically pressurized to 1125 psig. This pressure was held for five minutes.

6.2.2 Functional Test. The following functional tests were performed on each test sample to establish functional test criteria for environmental testing. These functional tests were repeated as often as practical throughout the environmental testing to verify sample operation within specification limits.

6.2.2.1 Position Indicator Switches. The position indicator switches were connected as shown in figure 4, appendix C. A position indicator was attached to the pinion gear on each test sample to measure the angle of the flow control gate from the fully open or fully closed position.

Each test sample was set up as shown in figures 5 and 6, appendix C. After the sample had stabilized at LN_2 temperature, a 90 psig LN_2 pressure was applied to the outlet port of the flow chamber. The flow control gate was operated a total of five cycles by applying a pneumatic pressure of 750 psig to the control piston assembly. Each cycle consisted of moving the flow gate from the fully closed position to the fully open position and back to the fully closed position.

Each sample satisfactorily operated within the following specification limits for all environmental conditions tested.

a. Deactuate (lose continuity between terminal pins A and C) at 12 degrees maximum from the fully closed position as the flow control gate leaves the closed position (see data sheet 1, appendix B).

b. Lose continuity between terminal pins B and E and gain continuity between pins B and D at 5 (±2) degrees from the fully open position as the flow control gate moves toward the open position (see data sheet 2, appendix B).

c. Lose continuity between terminal pins B and D and gain continuity between pins B and E at 12 degrees maximum from the fully open position as the flow control gate leaves the open position (see data sheet 3, appendix B).

d. Actuate (establish continuity between terminal pins A and C) at 5 (±2) degrees from the fully closed position as the flow control gate moves toward the closed position (see data sheet 4, appendix B).

6.2.2.2 Operating Time. The position indicator switches were connected to an oscillograph as shown in figure 4, appendix C.

Each test sample was set up as shown in figure 5 and 6, appendix C. After the test sample had stabilized at LN_2 temperature, LN_2 was allowed to flow through the valve for approximately 30 minutes at 90 psig pressure. A 750 psig pneumatic pressure was applied to the control piston solenoid valve. The sample was then operated a total of five cycles by actuating and deactuating the control piston solenoid valve. The time (in milliseconds) required for the flow control gate to move from the fully open position to the fully closed position and vice versa, as indicated by the position indicator switches, was measured and recorded.

Although the specification limit (1000 milliseconds maximum) was exceeded during the test program, (see data sheets 5 and 6, appendix B) it must be noted that the above tests were conducted in an LN_2 environment which is beyond the bounds of service conditions. Therefore, it is concluded that the LOX Replenishing Valve will satisfactorily operate under service conditions.

6.2.2.3 Leakage of Liquid Nitrogen. Each test sample was set up as shown in figures 5 and 6, appendix C. LN_2 was allowed to flow through the assembly until the sample had stabilized at LN_2 temperature. The following liquid nitrogen leakage checks were then performed on each sample.

6.2.2.3.1 Inlet Port. With the flow control gate in the fully closed position, a 50 psig LN_2 pressure was applied to the inlet port of the flow chamber. No liquid leakage is allowed past the gate seals, into the switch housing past the shaft seals, or externally.

Each test sample satisfactorily passed the inlet port leakage test for all environments (see data sheets 7 and 8, appendix B).

6.2.2.3.2 Outlet Port. With the flow control gate in the fully closed position, a 150 psig LN_2 pressure was applied to the outlet port of the flow chamber. No liquid leakage is allowed past the gate seals or externally.

Each test sample satisfactorily passed the outlet port leakage test for all environments (see data sheets 7 and 8, appendix B).

6.2.2.3.3 Both Ports. With the flow control gate in the fully open position, 150 psig LN_2 pressure was applied to the entire flow chamber. The allowable leakage is as follows:

a. Shaft seals - zero liquid leakage and 10.0 scim maximum gaseous leakage.

b. External - zero liquid and gaseous leakage.

c. Bellows and bellows seals - zero liquid and gaseous leakage.

Each test sample satisfactorily passed the both-ports leakage test for all environments except the post storage functional and the post shock test functional where excessive shaft seal leakage was noted on test sample 102 (see data sheet 9, appendix B) and the post high temperature functional on test sample 104 (see data sheet 10, appendix B).

6.2.2.4 Minimum Operating Pressure. Each test sample was set up as shown in figures 5 and 6, appendix C. LN_2 was allowed to flow through the assembly until the sample had stabilized at LN_2 temperature.

The outlet port of the flow chamber was pressurized to 90 psig with LN_2. Pneumatic pressure was applied upstream to the solenoid valve in 5 psig increments. The solenoid was actuated after each increase until the flow control gate fully opened. The maximum allowable pressure to fully open the flow control gate is 500 psig.

Each test sample satisfactorily passed the minimum operating pressure test for all environments (see data sheet 11, appendix B).

6.2.2.5 Control Piston Leakage. Each test sample was set up as shown in figures 5 and 6, appendix C. LN_2 was allowed to flow through the assembly until the sample was stabilized at LN_2 temperature. While the flow control gate was held in the fully open position with GN_2 at a pressure of 750 (±10) psig, the flow chamber was pressurized to 90(±2) psig with LN_2. The allowable leakage is as follows:

a. Bellows and bellows seals - zero allowable leakage.

b. External - zero allowable leakage.

Each test sample satisfactorily passed the control piston leakage check for all environments (see data sheet 12, appendix B).

6.2.2.6 Gaseous Nitrogen Leakage. Each test sample was set up as shown in figures 5 and 6, appendix C. With the test sample stabilized at ambient conditions the following leakage checks were performed.

6.2.2.6.1 Inlet Port. With the flow control gate in the fully closed position, the inlet port of the flow chamber was pressurized to 50 psig with GN_2. The allowable leakage is as follows:

a. Gate seal - 40 scim maximum gaseous leakage.

b. Shaft seals - 10 scim maximum gaseous leakage.

c. External - zero gaseous leakage.

Each test sample satisfactorily passed the inlet port gaseous nitrogen leakage test for all environments (see data sheets 13 and 14, appendix B).

6.2.2.6.2 Outlet Port. With the flow control gate in the fully closed position, the outlet port of the flow chamber was pressurized to 150 psig with GN_2. The allowable leakage past the gate seals is 40 scim maximum.

Each test sample satisfactorily passed the outlet port gaseous nitrogen leakage test for all environments (see data sheets 13 and 14, appendix B).

6.2.2.7 Resistance. Each test sample was set up as shown in figures 5 and 6, appendix C. LN_2 was allowed to flow through the assembly until the sample had stabilized at LN_2 temperature.

Each test sample satisfactorily passed the following resistance tests for all environments (see data sheets 15, 16, and 17, appendix B).

6.2.2.7.1 Insulation Resistance. The insulation resistance was measured for the following conditions with a 500V DC megger. The minimum allowable resistance is 50 megohms.

a. From each terminal pin of the electrical connector to the body of the valve assembly.

b. With the flow control gate closed:

(1) between terminal pins B and C

(2) between terminal pins D and E

(3) between terminal pins C and D

c. With the flow control gate open:

(1) between terminal pins A and C

(2) between terminal pins B and E

6.2.2.7.2 Contact Resistance. The contact resistance was measured for the following conditions. The maximum allowable contact resistance is 0.5 ohms.

a. With the flow control gate open: between terminal pins B and D.

b. With the flow control gate closed:

(1) between terminal pins A and C.

(2) between terminal pins B and E.

6.2.3 Dielectric Strength. The dielectric strength of the electrical components was demonstrated by each test sample, without failure, by applying 1000 volts rms alternating current for sixty seconds as follows (see table 2):

a. From each terminal pin of the electrical connector to the body of the valve assembly.

b. With the flow control gate in the fully closed position:

(1) between terminal pins B and C.

(2) between terminal pins C and D.

(3) between terminal pins D and E.

c. With the flow control gate in the fully open position:

(1) between terminal pins A and C.

(2) between terminal pins B and E.

Table 2. Dielectric Strength

	Terminal Pin	Microamperes Test Sample 102	104
Terminal Pin to Valve Body	A	10	20
	B	20	20
	C	10	25
	D	10	10
	E	10	20
Flow Control Gate Closed	B to C	20	30
	C to D	20	20
	D to E	20	90
Flow Control Gate Open	A to C	10	50
	B to E	20	20

6.2.4 High Temperature. The purpose of this test was to determine the ability of each test sample to operate satisfactorily when subjected to high environmental temperature levels.

Each test sample was installed in the functional test setup as shown in figures 5 and 6, appendix C. The internal temperature of the chamber was increased to +130°F and maintained for a period of 24 hours. Each test sample was then functionally tested as specified in paragraph 6.2.2 except 6.2.2.3. GN_2 was substituted for all functional tests requiring LN_2 as a pressurizing medium.

The sample's mass temperature was allowed to return to room ambient conditions and a functional test was then performed (see 6.2.2).

No failure or malfunction occurred during, or as a result of, high temperature testing on test sample 102. The sample functioned as required during all functional tests.

Shaft seal leakage (27 scim; 10 scim maximum allowable) was recorded on test sample 104 during the post high temperature functional test. Leakage occurred with the flow control gate open and the flow chamber pressurized to 150 psig. (See 6.2.2.3.3). This leakage was considered a marginal failure since shaft seal leakage had been observed on this sample during receiving inspection. Also, later in the test program a fabrication error was discovered which eliminated the shaft seal leakage on this test sample (see 6.2.9).

6.2.5 Humidity. The purpose of this test was to determine the ability of test sample 102 to operate satisfactorily after being subjected to a relative humidity of 95 percent for a period of 240 hours (10 days).

The inlet and outlet ports of the flow chamber were capped. The electrical connector was installed to simulate flight conditions. The test sample was placed in a Conrad environmental chamber (see figure 7, appendix C) which was between 68°F and 100°F with uncontrolled humidity. During the first two-hour period the temperature was gradually raised to 130°F and maintained for six hours. During the next 16-hour period the temperature was gradually reduced to between 68°F and 100°F. This 24-hour period constituted one cycle. The cycle was performed 10 times while maintaining the relative humidity at 95 percent.

During the test period, the insulation resistance (see 6.2.2.6.1) and the contact resistance (see 6.2.2.6.2) were measured and recorded a minimum of once in every 24-hour period. No failure or malfunction occurred during the humidity test (see data sheets 18 and 19, appendix B).

After the completion of the humidity test, the test sample was allowed to return to room ambient conditions. The valve was wiped dry and within one hour a functional test was performed (see 6.2.2).

No failure or malfunction occurred as a result of humidity testing on test sample 102. The sample functioned as required during all functional tests.

6.2.6 Salt Spray. The purpose of this test was to determine the ability of test sample 102 to operate satisfactorily after being subjected to a five percent solution salt spray at a temperature of 95°F for a period of 24 hours.

The inlet and outlet ports of the flow chamber were capped. The electrical connector was installed to simulate flight conditions. The valve assembly was then installed in a salt spray chamber (see figure 8, appendix C) and exposed to a salt spray for 24 hours as specified in method 811.1 of Federal Test Method, Standard 151a. After the completion of the 24-hour period the valve was removed from the salt spray chamber, rinsed with tap water and a functional test was performed (see 6.2.2.).

No failure or malfunction occurred as a result of the 24-hour salt spray testing on test sample 102. The sample functioned as required during all functional tests.

The valve was stored for a period of 48 hours and then functionally tested again.

With the flow control gate in the open position and the flow chamber pressurized to 150 psig, shaft seal leakage (110 scim; 10 scim maximum allowable) was recorded (see 6.2.2.3.3). Because a fabrication error was found later in the test program (see 6.2.9), this leakage was considered a marginal failure.

No other failures or malfunctions occurred as a result of salt spray testing.

17

6.2.7 Vibration. In order to simulate the dynamic charcteristics of the vehicle installation, each test sample was installed on an MB vibration exciter (model C-210) along with the reducing elbow (P/N 20M00830), flex hose (P/N 20M00031) and clamp assembly (P/N 10C10680) as shown in figure 9, appendix C. Each sample was then subjected to vibration tests along each of its three major axes.

Liquid nitrogen was allowed to flow through the valve until it stabilized at LN_2 temperature. The sample was then subjected to a logarithmic scan along each of its three major axes over a frequency range from 20 to 2000 cps at a rate of 0.67 octaves/minute (6 2/3 octaves total) at the following input levels:

20 to 28 cps at 0.2-inch DA displacement

28 to 72 cps at 8.0g peak

72 to 140 cps at 0.03-inch DA displacement

140 to 2000 cps at 30.0g peak

The test sample was then subjected to five minutes of vibration at each of two major resonance frequencies per axis as described in table 3.

Table 3. Resonant Frequencies

Sample	Axis	Vibration Period (minutes)	Input	Resonant Frequency (cps)
102	Y	5	15g	480
		5	15g	680
	Z	5	0.015-inch DA displacement	118
		5	15g	1190
	X	5	0.015-inch DA displacement	110
		5	15g	960
104	Y	5	15g	320
		5	15g	540
	Z	5	0.015-inch DA displacement	118
		5	15g	650
	X	5	0.015-inch DA displacement	98
		5	15g	1300

During the sweep and dwell along each major axis, the outlet port of each test sample was pressurized to 90 psig with LN_2 while the flow control gate was in the closed position. The leakage externally and past the gate seals was measured and recorded during each vibration test. Also, the position indicator switches were monitored throughout the test for erroneous indications or contact chatter (see table 4). At the completion of each sweep and dwell a functional test was conducted on each test sample (see 6.2.2).

Table 4. Vibration Operating Data

Sample	Axis	Level	External Leakage	Gate Seal Leakage	Contact Chatter
102	Y	Sweep	0	0	None
		1st Dwell	0	0	None
		2nd Dwell	0	0	None
	Z	Sweep	0	0	None
		1st Dwell	0	0	None
		2nd Dwell	0	0	None
	X	Sweep	0	0	None
		1st Dwell	0	0	None
		2nd Dwell	0	0	None
104	Y	Sweep	0	0	None
		1st Dwell	0	0	None
		2nd Dwell	0	0	None
	Z	Sweep	0	0	None
		1st Dwell	0	0	None
		2nd Dwell	0	0	None
	X	Sweep	0	0	None
		1st Dwell	0	0	None
		2nd Dwell	0	0	None

No failure or malfunction occurred during, or as a result of, vibration testing. Each test sample functioned as required during all functional tests.

In order to reflect the latest document changes in the dynamic environment for qualification testing, (Preliminary Vibration, Acoustic, and Shock Specification for Components on Saturn IB Vehicle, IN-P&VE-S-63-1, revised September 11, 1964), tests were conducted on test sample 104 at the vibration levels not covered in technical procedure TP-RE-64-43.

Test sample 104 was subjected to a logarithmic scan along each of its three major axes over a frequency range from 5 to 2000 cps and from 2000 to 5 cps at a rate of one octave/minute along each of the sample's major axes at the following input levels:

5 to 28 cps at 0.2-inch DA displacement

28 to 72 cps at 8.0g peak

72 to 140 cps at 0.03-inch DA displacement

140 to 2000 cps at 30.0g peak

The test sample was then subjected to a five-minute random vibration along each of its three major axes under the following conditions:

From 20 to 2000 cps at $0.21g^2$/cps power spectral density.

No failure or malfunction occurred during, or as a result of, vibration testing per IN-P&VE-S-63-1, revised September 11, 1964. The test sample functioned as required during all functional tests.

6.2.8 Impact Shock. Each test sample was attached to a Barry impact shock machine, model 15000, and subjected to six shocks along each of its three major axes (see figure 10, appendix C). Three 50g half-sine wave shocks, for a duration of ten milliseconds, were applied in each direction of each axis for a total of eighteen shocks (see figure 11, appendix C).

Liquid nitrogen was allowed to flow through each assembly until the valve had stabilized at LN_2 temperature. During each shock, the outlet port of each test sample was pressurized to 90 psig with LN_2 while the flow control gate was in the closed position. The leakage externally and past the gate seals was measured and recorded during each shock. Also, the position indicator switches were monitored for erroneous indications or contact chatter. At the completion of the shock test a functional test was conducted on each test sample (see 6.2.2).

With the flow control gate in the open position and the flow chamber pressurized to 150 psig, shaft seal leakage (30 scim; 10 scim maximum allowable) was recorded for test sample 102 (see 6.2.2.3.3). Because a fabrication error was found later in the test program (see 6.2.9), this failure was considered a marginal failure.

20

No other failure or malfunction occurred during, or as a result of, impact shock testing. Each sample functioned as required during all functional tests.

6.2.9 Life Cycle. The purpose of this test was to determine the ability of each test sample to operate satisfactorily for 1000 cycles. Each sample was operated at a rate of six seconds per cycle in a sequence as shown below:

a) 400 cycles with the valve stabilized at room ambient temperature.

b) 200 cycles with the valve stabilized at +130°F.

c) 300 cycles with the entire flow chamber pressurized to 90 psig with LN_2 (no flow).

d) 100 cycles with the outlet port (tank end) of the flow chamber pressurized to 150 psig with LN_2 (flow when gate is open).

The position indicator switches were energized (28V DC) and a resistive load was added to obtain a current of 3.0 amperes when the contacts were closed. Each cycle was performed with a control piston pressure of 750 psig. After each temperature phase a functional test was conducted (see 6.2.2).

Excessive shaft seal leakage was observed during the post test functional for temperature phase b on sample 102.

The shaft seals were removed and excessive degradation of the seals was noted (see figure 12, appendix C). Also, the rms finish of the shaft did not meet the drawing requirements (16 rms required; 40 rms actual). The O. D. of the shaft was reworked to a 13 rms finish and new shaft seals were installed. A complete life cycle test was then conducted on sample 102.

No failure or malfunction occurred during, or as a result of, life cycle testing. Test sample 102 functioned as required during all functional tests.

Since Receiving Inspection had observed shaft seal leakage in three of the six valves tested (see appendix E), test sample 104 was disassembled and inspected before conducting the life cycle test. The rms finish of the shaft did not meet the drawing requirements (16 rms required; 45 rms actual). The shaft was reworked to a 16 rms or better finish and new shaft seals were installed. The life cycle test was then conducted on test sample 104.

No failure or malfunction occurred during, or as a result of, life cycle testing. Test sample 104 functioned as required during all functional tests.

6.2.10 Burst Pressure. Each test sample was installed in a burst chamber (see figure 13, appendix C) and subjected to the burst pressure tests described in 6.2.10.1 and 6.2.10.2 at room ambient conditions. No failure or malfunction occurred during, or as a result of, burst pressure testing.

6.2.10.1 Flow Chamber. With the flow control gate in the fully closed position, the outlet port of the flow chamber was pneumatically pressurized to 375 psig.

This pressure was held for three minutes. The flow control gate was then closed and the inlet port vented. The outlet port was again pneumatically pressurized to 375 psig and held for three minutes.

6.2.10.2 Control Piston. With the flow chamber vented, the control piston was pneumatically pressurized to 1875 psig. This pressure was held for three minutes.

37

APPENDIX A

Component Check Sheet

DO NOT [illegible]

COMPONENT CHECK SHEET

FOR THE

LOX REPLENISHING VALVE

(60C20457)

I. SUPPLY SOURCE

A. Manufacturer: Parker Aircraft Company

B. Manufacturer's Part Number: 2630287

II. FUNCTIONAL CHARACTERISTICS

A. Flow Chamber

1. Service media: liquid oxygen, liquid nitrogen or air

2. Operating pressure: 150 psig

3. Proof Pressure: 225 psig

4. Burst Pressure: 375 psig

5. Allowable leakage

5.1 Pneumatic Pressure

5.1.1 With inlet port of flow chamber pressurized to 50 psig with GN_2.

(a) 40 scim past main gate seal (max)

(b) 10 scim past shaft seals (max)

(c) Zero external

5.1.2 With the outlet port (tank end) of the flow chamber pressurized to 150 psig with GN_2 the maximum allowable leakage past the main gate seal shall be 40 scim.

5.2 Liquid Pressure

5.2.1 Main Gate Seal - zero liquid leakage allowed past the main gate seal when the outlet port (tank end) of the flow chamber is pressurized from zero to 90 psig with LOX or LN_2 with the flow control gate in the fully closed position.

5.2.2 Shaft Seals - zero liquid leakage and 10 scim maximum gaseous leakage with the entire flow chamber pressurized from zero to 150 psig with LOX or LN_2.

5.2.3 External - zero liquid or gaseous external leakage with the entire flow chamber pressurized to 150 psig with LOX or LN_2. Flow from bleeds or vents shall not be considered external leakage.

5.2.4 Bellows and bellows seals - zero liquid or gaseous leakage past the bellows and bellows seals with the entire flow chamber pressurized from zero to 150 psig with LOX or LN_2.

B. Control Piston Assembly

1. Service media: air, helium or GN_2
2. Operating Pressure: 750 psig
3. Proof Pressure: 1125 psig
4. Burst Pressure: 1875 psig
5. Allowable leakage

   5.1 Bellows and bellows seals - zero leakage allowed past the bellows and bellows seals with the control piston assembly pressurized to 750 psig with GN_2.

   5.2 External - zero allowable leakage with the control piston assembly pressurized to 750 psig with GN_2.

6. Minimum operating pressure - the maximum allowable pressure required for the control piston assembly to move the flow control gate from the fully closed to the fully open position is 500 psig while maintaining a minimum LN_2 pressure of 90 psig on the flow chamber.
7. Minimum operating time - the maximum operating (response) time required to move the flow control gate from the fully closed to the fully open position or vice versa is 1000 milliseconds while maintaining a minimum LN_2 pressure of 90 psig on the flow chamber.

III. ELECTRICAL CHARACTERISTICS

A. Operating Voltage: 22 to 32 V DC

B. Contact Resistance: 0.5 ohms maximum

C. Insulation Resistance: 50 megohms maximum at 500V DC

D. Position Indication

1. Closed Position Switch

   1.1 Actuate at 5 degrees (±2 degrees) from the fully closed position as the flow gate moves toward the fully closed position.

   1.2 Deactuate at 12 degrees maximum from the fully closed position as the flow gate moves away from the closed position.

2. Open position switch

2.1 Actuate (terminal pins B and D) at 5 degrees (±2 degrees) from the fully open position as the flow gate moves toward the open position.

2.2 Deactuate (terminal pins B and D) at 12 degrees maximum from the fully open position as the flow gate moves away from the open position.

IV. CONSTRUCTION

A. Body material: aluminum

B. Weight: 10 pounds

C. Finish: anodized

D. Pressure Port: MC 240-4

E. Connector Type: MS 3102R 149-5P

F. Type of Seat: Ball

G. Seat Material: Teflon

H. Seal Material: Teflon

V. ENVIRONMENTAL CHARACTERISTICS

A. Temperature: -320°F to +130°F

B. Humidity: MIL-E-5272 Procedure I

C. Salt Spray: MIL-E-5272, Procedure I

D. Vibration: 5 - 2000 cps 30g

E. Shock: 50g

VI. SPECIAL REQUIREMENTS

A. Control Specification: 60C2612

B. Marking Specification: MIL-STD-130

VII. SAMPLE FUNCTION AND LOCATION

The LOX Replenishing Valve will be used on Saturn S-IB Stages to make final weight adjustments by adding or draining LOX from the LOX tanks. It is located near the bottom of LOX tank O-4 at station 207.

APPENDIX B

Data Sheets

Data Sheet 1. Angle of Valve When Closed Position Switch Deactuates (Closed to Open Operation)

	Valve Angle From Fully Closed Position in Degrees (12° Max.)									
	Sample Number 102					Sample Number 104				
	1	2	3	4	5	1	2	3	4	5
Pretest Functional	10	10.5	10	7	10	9	10	9.5	9.5	9.5
High Temperature Functional	3	3	3	3	3	4	5	8.5	8	9
Post High Temp. Functional	8	9	9	7	8	9	8	8	8	8
Post Humidity Functional	10	9	7	10	10					
Post Salt Spray Functional	5	6	6	6	6					
Post Storage Functional	5.5	6	6	5.5	5.5					
Post Y-Axis Sweep Functional	-	-	-	-	-	8	8	8	9	8
Post Y-Axis Dwell Functional	-	-	-	-	-	9	8	8	9	8
Post Z-Axis Sweep Functional	-	-	-	-	-	9	8	8.5	9	8
Post Z-Axis Dwell Functional	-	-	-	-	-	9	8	8	8	9
Post X-Axis Sweep Functional	7	6	6	5.5	6	8.5	8	8	9	8
Post X-Axis Dwell Functional	7	8	8	9	8	9	8	8	9	8
Post Shock Functional	10	11	9	10	9	8	8	9	9	9
Post 400 Cycles @ Ambient	6	5	5	5	6	9	8	8	8	8
Post 200 Cycles @ + 130° F	5	5	4	5	5	8.5	9	9	9	10
Post 300 Cycles with 90 psig LN_2	5	5	4.5	6	5	9	9	9	9	9
Post 100 Cycles with 150 psig LN_2	6	5	4	5	5	8	8	9	9	9

Data Sheet 2. Angle of Valve When Open Position Switch Actuates (Closed to Open Operation)

	Valve Angle From Fully Open Position in Degrees (3° to 7°)									
	Sample Number 102					Sample Number 104				
	1	2	3	4	5	1	2	3	4	5
Pretest Functional	6.5	6	6.5	7	6.5	5	5	5.5	5	5
High Temperature Functional	5.5	6	6	6.5	6	6	6	5	4	4
Post High Temp. Functional	6	5	5.5	6	6	5	6	6	6	6
Post Humidity Functional	6.5	6	5.5	6	5.5					
Post Salt Spray Functional	6	6	6	6	6					
Post Storage Functional	5	5	5	5	5					
Post Y-Axis Sweep Functional	-	-	-	-	-	6	6	5	5	6
Post Y-Axis Dwell Functional	-	-	-	-	-	5	6	6	6	6
Post Z-Axis Sweep Functional	-	-	-	-	-	5	6	5	6	6
Post Z-Axis Dwell Functional	-	-	-	-	-	6	5	5	6	6
Post X-Axis Sweep Functional	6	6	6	6	6	6	6	6	6	5
Post X-Axis Dwell Functional	6	6	6	5	5	6	5	6	6	6
Post Shock Functional	5	5	6	5	6	6	5	5	5	5
Post 400 Cycles @ Ambient	4	4.5	4.5	5	4	5	5	5	5	5
Post 200 Cycles @ + 130° F	6	6	5	6	6	5	5	5	5	5
Post 300 Cycles with 90 psig LN_2	5	4	4	4	4	5	5	5	5	5
Post 100 Cycles with 150 psig LN_2	4	4	4	5	4	5	6	5	5	5

27

Data Sheet 3. Angle of Valve When Open Position Switch Deactuates
(Open to Closed Operation)

	Valve Angle From Fully Open Position in Degrees (12° Max.)									
	Sample Number 102					Sample Number 104				
	1	2	3	4	5	1	2	3	4	5
Pretest Functional	8	10	10	10	9	8.5	8	9	8.5	9
High Temperature Functional	5	3.5	7	4.5	4	8	8	8	8	8
Post High Temp. Functional	5	5	5	5	4.5	10	10	10	10	10
Post Humidity Functional	5	5	4	5	5.5					
Post Salt Spray Functional	7	7	7	6	7					
Post Storage Functional	5	4.5	5	5	5					
Post Y-Axis Sweep Functional	-	-	-	-	-	9	10	10	9	10
Post Y-Axis Dwell Functional	-	-	-	-	-	9	9	10	9	9
Post Z-Axis Sweep Functional	-	-	-	-	-	9	9	10	9	10
Post Z-Axis Dwell Functional	-	-	-	-	-	9	10	9	9	10
Post X-Axis Sweep Functional	5	7	6	5	5	9	10	10	9	9
Post X-Axis Dwell Functional	5	5	5	7	6	9	10	10	10	9
Post Shock Functional	7	4	6	7	6	10	10	9	9	10
Post 400 Cycles @ Ambient	8	9	9	9	8	9	10	9	9	9
Post 200 Cycles @ + 130° F	9	9	9	9	9	9	8	8	8	8
Post 300 Cycles with 90 psig LN_2	6.5	6	7	7	6.5	9	10	9	9	9
Post 100 Cycles with 150 psig LN_2	9	9	9	9	9	9	9	9	9	9

Data Sheet 4. Angle of Valve When Closed Position Switch Actuates
(Open to Closed Operation)

	Valve Angle From Fully Closed Position in Degrees (3° to 7°)									
	Sample Number 102					Sample Number 104				
	1	2	3	4	5	1	2	3	4	5
Pretest Functional	5	5	6	6	5	4	4	4	5	5
High Temperature Functional	5	5.5	5	5	5	7	4	4.5	4.5	4.5
Post High Temp. Functional	6	6	5.5	5.5	6	4	4.5	4	4	4
Post Humidity Functional	6	6.5	6.5	6	6					
Post Salt Spray Functional	5.5	5.5	5	6	5					
Post Storage Functional	6	6	6	6	6					
Post Y-Axis Sweep Functional	-	-	-	-	-	5	4	4	4.5	4
Post Y-Axis Dwell Functional	-	-	-	-	-	4	4.5	4.5	4	4
Post Z-Axis Sweep Functional	-	-	-	-	-	5	5	5	4	4
Post Z-Axis Dwell Functional	-	-	-	-	-	5	5	4	4	4
Post X-Axis Sweep Functional	6	5	6	6	6	4	5	4	4	4
Post X-Axis Dwell Functional	6	6	5	5	5	5	4	4	4.5	4
Post Shock Functional	6	6	5	6	6	4	4	4.5	5	5
Post 400 Cycles @ Ambient	3	3	3.5	3.5	3.5	5	5	5	5	5
Post 200 Cycles @ + 130° F	3	3	3	3	3	5	4	5	5	5
Post 300 Cycles with 90 psig LN_2	4	4	4	4.5	4	5	4	5	5	5
Post 100 Cycles with 150 psig LN_2	4	4	4	4.5	4	5	5	5	5	5

Data Sheet 5. Test Sample 102, Operating Time At LN_2 Temperature With 90 psig on Flow Chamber

Limit: 1000 Milliseconds Max.

	Operating Time In Milliseconds									
	Closed to Open					Open to Closed				
	1	2	3	4	5	1	2	3	4	5
Pretest Functional	74	71	70	-	-	880	817	767	-	-
High Temperature Functional	47	49	49	-	-	240	240	240	-	-
Post High Temp. Functional	68	70	67	-	-	572	535	538	-	-
Post Humidity Functional	292	245	227	224	217	937	732	700	656	644
Post Salt Spray Functional	82	310	300	299	294	831	*1060	935	893	-
Post Storage Functional	258	248	240	251	247	740	620	589	605	561
Post Y-Axis Sweep Functional	-	-	-	-	-	-	-	-	-	-
Post Y-Axis Dwell Functional	-	-	-	-	-	-	-	-	-	-
Post Z-Axis Sweep Functional	-	-	-	-	-	-	-	-	-	-
Post Z-Axis Dwell Functional	-	-	-	-	-	-	-	-	-	-
Post X-Axis Sweep Functional	345	348	410	397	421	*1028	778	761	746	673
Post X-Axis Dwell Functional	-	389	404	408	420	857	743	707	666	627
Post Shock Functional	263	250	138	110	82	715	315	310	250	226
Post 400 Cycles @ Ambient (A)	182	164	155	145	143	884	548	500	470	452
Post 200 Cycles @ + 130° F	-	201	193	190	180	684	552	510	478	470
Post 300 Cycles with 90 psig LN_2	354	333	320	308	-	*1352	682	680	636	-
Post 100 Cycles with 150 psig LN_2	334	308	298	289	293	*1200	723	621	563	550

* Exceeds Specification Limit

(A) New Shaft Seals Installed (See 6.2.9)

Data Sheet 6. Test Sample 104, Operating Time At LN_2 Temperature
With 90 psig on Flow Chamber

Limit: 1000 Milliseconds Max.

	Operating Time In Milliseconds									
	Closed to Open					Open to Closed				
	1	2	3	4	5	1	2	3	4	5
Pretest Functional	-	354	346	339	336	-	465	440	424	400
High Temperature Functional	63	67	72	77	81	185	174	174	176	176
Post High Temp. Functional	280	283	270	251	245	612	560	498	485	457
Post Humidity Functional										
Post Salt Spray Functional										
Post Storage Functional										
Post Y-Axis Sweep Functional	437	417	424	410	420	*1090	790	814	763	720
Post Y-Axis Dwell Functional	466	427	413	398	396	597	515	488	477	460
Post Z-Axis Sweep Functional	393	390	404	402	388	885	671	630	618	601
Post Z-Axis Dwell Functional	427	450	410	410	405	876	594	620	590	610
Post X-Axis Sweep Functional	500	475	486	500	-	638	512	500	491	-
Post X-Axis Dwell Functional	427	450	410	410	405	876	594	620	590	610
Post Shock Functional	460	440	420	425	400	900	630	570	490	475
Post 400 Cycles @ Ambient (A)	443	397	380	390	388	570	510	483	476	467
Post 200 Cycles @ + 130° F	460	448	400	384	370	700	640	620	540	520
Post 300 Cycles with 90 psig LN_2	486	465	423	390	388	885	620	560	540	475
Post 100 Cycles with 150 psig LN_2	447	394	386	384	379	860	725	597	570	565

* Exceeds Specification Limit
(A) New Shaft Seals Installed (See 6.2.9)

Data Sheet 7. Test Sample 102, LN_2 Leakage With Flow Control Gate Closed (SCIM)

Limit: No Liquid Leakage Allowed

	Inlet Port Pressurized 50 psig LN_2			Outlet Port Pressurized 150 psig LN_2	
	External	Gate Seals	Shaft Seals	External	Gate Seals
Pretest Functional	0	0	0	0	0
High Temperature Functional					
Post High Temp. Functional	0	0	0	0	0
Post Humidity Functional	0	0	0	0	0
Post Salt Spray Functional	0	0	0	0	0
Post Storage Functional	0	0	0	0	0
Post Y-Axis Sweep Functional	-	-	-	-	-
Post Y-Axis Dwell Functional	-	-	-	-	-
Post Z-Axis Sweep Functional	-	-	-	-	-
Post Z-Axis Dwell Functional	-	-	-	-	-
Post X-Axis Sweep Functional	0	0	0	0	0
Post X-Axis Dwell Functional	0	0	0	0	0
Post Shock Functional	0	0	0	0	0
Post 400 Cycles @ Ambient	0	0	0	0	0
Post 200 Cycles @ + 130° F	0	0	0	0	0
Post 300 Cycles with 90 psig LN_2	0	0	0	0	0
Post 100 Cycles with 150 psig LN_2	0	0	0	0	0

32

Data Sheet 8. Test Sample 104, LN_2 Leakage With Flow Control Gate Closed (SCIM)

Limit: No Liquid Leakage Allowed

	Inlet Port Pressurized 50 psig LN_2			Outlet Port Pressurized 150 psig LN_2	
	External	Gate Seals	Shaft Seals	External	Gate Seals
Pretest Functional	0	0	0	0	0
High Temperature Functional					
Post High Temp. Functional	0	0	0	0	0
Post Humidity Functional					
Post Salt Spray Functional					
Post Storage Functional					
Post Y-Axis Sweep Functional	0	0	0	0	0
Post Y-Axis Dwell Functional	0	0	0	0	0
Post Z-Axis Sweep Functional	0	0	0	0	0
Post Z-Axis Dwell Functional	0	0	0	0	0
Post X-Axis Sweep Functional	0	0	0	0	0
Post X-Axis Dwell Functional	0	0	0	0	0
Post Shock Functional	0	0	0	0	0
Post 400 Cycles @ Ambient	0	0	0	0	0
Post 200 Cycles @ + 130° F	0	0	0	0	0
Post 300 Cycles with 90 psig LN_2	0	0	0	0	0
Post 100 Cycles with 150 psig LN_2	0	0	0	0	0

Data Sheet 9. Test Sample 102, Leakage At LN_2 Temperature With Flow Control Gate Open (SCIM)

Limit: (1) No Leakage Allowed
(2) 10 SCIM Maximum

	Both Ports Pressurized 150 psig LN_2					
	Shaft Seals		External		Bellows and Bellows Seals	
	(1) Liquid	(2) Gas	(1) Liquid	(1) Gas	(1) Liquid	(1) Gas
Pretest Functional	0	0	0	0	0	0
High Temperature Functional						
Post High Temp. Functional	0	0	0	0	0	0
Post Humidity Functional	0	0	0	0	0	0
Post Salt Spray Functional	0	0	0	0	0	0
Post Storage Functional	0	110**	0	0	0	0
Post Y-Axis Sweep Functional	-	-	-	-	-	-
Post Y-Axis Dwell Functional	-	-	-	-	-	-
Post Z-Axis Sweep Functional	-	-	-	-	-	-
Post Z-Axis Dwell Functional	-	-	-	-	-	-
Post X-Axis Sweep Functional	0	0	0	0	0	0
Post X-Axis Dwell Functional	0	0	0	0	0	0
Post Shock Functional	0	30**	0	0	0	0
Post 400 Cycles @ Ambient (A)	0	0	0	0	0	0
Post 200 Cycles @ + 130° F	0	0	0	0	0	0
Post 300 Cycles with 90 psig LN_2	0	0	0	0	0	0
Post 100 Cycles with 150 psig LN_2	0	0	0	0	0	0

** GN_2 Leakage

(A) Excessive Shaft Seal Leakage Recorded. New Shaft Seals Installed and Life Cycle Test Repeated

34

Data Sheet 10. Test Sample 104, Leakage At LN_2 Temperature With Flow Control Gate Open (SCIM)

Limit: (1) No Leakage Allowed
(2) 10 SCIM Maximum

	Both Ports Pressurized 150 psig LN_2					
	Shaft Seals		External		Bellows and Bellows Seals	
	(1) Liquid	(2) Gas	(1) Liquid	(1) Gas	(1) Liquid	(1) Gas
Pretest Functional	0	0	0	0	0	0
High Temperature Functional						
Post High Temp. Functional	0	27*	0	0	0	0
Post Humidity Functional						
Post Salt Spray Functional						
Post Storage Functional						
Post Y-Axis Sweep Functional	0	0	0	0	0	0
Post Y-Axis Dwell Functional	0	0	0	0	0	0
Post Z-Axis Sweep Functional	0	0	0	0	0	0
Post Z-Axis Dwell Functional	0	0	0	0	0	0
Post X-Axis Sweep Functional	0	0	0	0	0	0
Post X-Axis Dwell Functional	0	0	0	0	0	0
Post Shock Functional	0	0	0	0	0	0
Post 400 Cycles @ Ambient	0	0	0	0	0	0
Post 200 Cycles @ + 130° F	0	0	0	0	0	0
Post 300 Cycles with 90 psig LN_2	0	7	0	0	0	0
Post 100 Cycles with 150 psig LN_2	0	0	0	0	0	0

* Exceeds Specification Limit

Data Sheet 11. Minimum Operating Pressure at LN_2 Temperature With 90 PSIG on Flow Chamber

Limit: 500 PSIG Maximum

	Minimum Operating Pressure in PSIG					
	Sample Number 102			Sample Number 104		
	Cycle			Cycle		
	1	2	3	1	2	3
Pretest Functional	450	425	425	460	400	460
High Temperature Functional	335	332	330	440	443	445
Post High Temperature Functional	480	460	468	400	430	465
Post Humidity Functional	460	420	430			
Post Salt Spray Functional	480	450	400			
Post Storage Functional	480	465	460			
Post Y-Axis Sweep Functional	-	-	-	435	425	430
Post Y-Axis Dwell Functional	-	-	-	450	430	435
Post Z-Axis Sweep Functional	-	-	-	440	435	435
Post Z-Axis Dwell Functional	-	-	-	445	440	430
Post X-Axis Sweep Functional	470	440	440	430	445	440
Post X-Axis Dwell Functional	480	430	435	440	430	435
Post Shock Functional	405	410	400	460	480	470
Post 400 Cycles @ Ambient	410	360	408	480	480	495
Post 200 Cycles @ + 130°F	400	345	400	490	495	480
Post 300 Cycles with 90 PSIG LN_2	440	480	485	488	475	450
Post 100 Cycles with 150 PSIG LN_2	460	430	440	485	495	490

36

Data Sheet 12. Control Piston Leakage of GN_2 at LN_2 Temperature
With 90 PSIG on Flow Chamber

Limit: No Leakage Allowed

	Control Piston Leakage			
	Sample Number 102		Sample Number 104	
	External	Bellows and Bellows Seals	External	Bellows and Bellows Seals
Pretest Functional	0	0	0	0
High Temperature Functional	0	0	0	0
Post High Temperature Functional	0	0	0	0
Post Humidity Functional	0	0		
Post Salt Spray Functional	0	0		
Post Storage Functional	0	0		
Post Y-Axis Sweep Functional	-	-	0	0
Post Y-Axis Dwell Functional	-	-	0	0
Post Z-Axis Sweep Functional	-	-	0	0
Post Z-Axis Dwell Functional	-	-	0	0
Post X-Axis Sweep Functional	0	0	0	0
Post X-Axis Dwell Functional	0	0	0	0
Post Shock Functional	0	0	0	0
Post 400 Cycles @ Ambient	0	0	0	0
Post 200 Cycles @ + 130°F	0	0	0	0
Post 300 Cycles with 90 PSIG LN_2	0	0	0	0
Post 100 Cycles with 150 PSIG LN_2	0	0	0	0

Data Sheet 13. Test Sample 102, GN_2 Leakage With Flow Control Gate Closed (SCIM)

Limit: (1) No Leakage Allowed
(2) 40 Scim Maximum
(3) 10 Scim Maximum

	Inlet Port Pressurized 50 PSIG GN_2			Outlet Port Pressurized 150 PSIG GN_2	
	(1) External	(2) Gate Seals	(3) Shaft Seals	(1) External	(2) Gate Seals
Pretest Functional	0	0	0	0	0
High Temperature Functional	0	0	0	0	0
Post High Temp. Functional	0	0	0	0	0
Post Humidity Functional	0	0	0	0	0
Post Salt Spray Functional	0	0	0	0	0
Post Storage Functional	0	0	0	0	0
Post Y-Axis Sweep Functional	-	-	-	-	-
Post Y-Axis Dwell Functional	-	-	-	-	-
Post Z-Axis Sweep Functional	-	-	-	-	-
Post Z-Axis Dwell Functional	-	-	-	-	-
Post X-Axis Sweep Functional	0	0	0	0	0
Post X-Axis Dwell Functional	0	0	0	0	0
Post Shock Functional	0	0	0	0	0
Post 400 Cycles @ Ambient	0	0	0	0	0
Post 200 Cycles @ +130°F	0	0	0	0	0
Post 300 Cycles With 90 PSIG LN_2	0	0	0	0	0
Post 100 Cycles With 150 PSIG LN_2	0	0	0	0	0

Data Sheet 14. Test Sample 104, GN_2 Leakage With Flow Control Gate Closed (SCIM)

Limit: (1) No Leakage Allowed
(2) 40 Scim Maximum
(3) 10 Scim Maximum

	Inlet Port Pressurized 50 PSIG GN_2			Outlet Port Pressurized 150 PSIG GN_2	
	(1) External	(2) Gate Seals	(3) Shaft Seals	(1) External	(2) Gate Seals
Pretest Functional	0	0	0	0	0
High Temperature Functional	0	0	0	0	0
Post High Temp. Functional	0	0	0	0	0
Post Humidity Functional					
Post Salt Spray Functional					
Post Storage Functional					
Post Y-Axis Sweep Functional	0	0	0	0	0
Post Y-Axis Dwell Functional	0	0	0	0	0
Post Z-Axis Sweep Functional	0	0	0	0	0
Post Z-Axis Dwell Functional	0	0	0	0	0
Post X-Axis Sweep Functional	0	0	0	0	0
Post X-Axis Dwell Functional	0	0	0	0	0
Post Shock Functional	0	0	0	0	0
Post 400 Cycles @ Ambient	0	0	0	0	0
Post 200 Cycles @ + 130°F	0	0	0	0	0
Post 300 Cycles With 90 PSIG LN_2	0	0	0	0	0
Post 100 Cycles With 150 PSIG LN_2	0	0	0	0	0

Data Sheet 15. Test Sample 102, Insulation Resistance (1000 Megohms)

Limit: 50 Megohms Minimum	Terminal To Valve Body					Terminal to Terminal				
						Valve Closed			Valve Open	
	A	B	C	D	E	B to C	D to E	C to D	A to C	B to E
Pretest Functional	400	500	500	150	200	100	500	70	200	60
High Temperature Functional	0.40	0.35	0.50	0.60	0.40	0.60	0.50	0.60	0.60	0.40
Post High Temperature Functional	30	40	30	40	30	20	40	20	40	30
Post Humidity Functional	10	9	8	8	7	4.5	6	3.8	10	20
Post Salt Spray Functional	20	10	15	15	14	13	15	15	15	15
Post Storage Functional	50	50	30	70	30	40	50	40	50	100
Post Y-Axis Sweep Functional	-	-	-	-	-	-	-	-	-	-
Post Y-Axis Dwell Functional	-	-	-	-	-	-	-	-	-	-
Post Z-Axis Sweep Functional	-	-	-	-	-	-	-	-	-	-
Post Z-Axis Dwell Functional	-	-	-	-	-	-	-	-	-	-
Post X-Axis Sweep Functional	50	50	50	55	45	20	40	50	40	60
Post X-Axis Dwell Functional	45	180	300	200	300	160	250	20	30	20
Post Shock Functional	30	20	40	70	30	30	35	40	50	40
Post 400 Cycles @ Ambient	20	20	20	20	20	15	30	40	40	40
Post 200 Cycles @ +130°F	30	40	50	30	50	20	30	20	20	20
Post 300 Cycles With 90 PSIG LN_2	20	30	45	40	50	20	25	30	20	30
Post 100 Cycles With 150 PSIG LN_2	15	15	20	20	30	20	30	20	20	20

40

Data Sheet 16. Test Sample 104, Insulation Resistance (1000 Megohms)

Limit: 50 Megohms Minimum	Terminal To Valve Body					Terminal to Terminal				
						Valve Closed			Valve Open	
	A	B	C	D	E	B to C	D to E	C to D	A to C	B to E
Pretest Functional	35	30	40	60	40	35	50	55	45	50
High Temperature Functional	10	7	13	17	10	7	10	10	15	12
Post High Temperature Functional	100	50	100	50	50	40	60	50	50	100
Post Humidity Functional										
Post Salt Spray Functional										
Post Storage Functional										
Post Y-Axis Sweep Functional	20	30	30	30	30	20	30	40	30	20
Post Y-Axis Dwell Functional	30	40	30	30	20	30	40	30	30	20
Post Z-Axis Sweep Functional	100	50	70	40	70	100	60	50	70	70
Post Z-Axis Dwell Functional	25	30	30	40	30	30	40	30	40	30
Post X-Axis Sweep Functional	30	30	40	40	30	40	40	30	40	30
Post X-Axis Dwell Functional	40	40	30	40	30	40	40	40	30	40
Post Shock Functional	70	30	50	50	50	40	30	25	30	25
Post 400 Cycles @ Ambient	50	50	60	60	50	40	50	40	40	50
Post 200 Cycles @ + 130°F	70	60	80	70	80	60	70	50	70	60
Post 300 Cycles with 90 PSIG LN_2	50	50	40	60	60	40	50	60	50	40
Post 100 Cycles with 150 PSIG LN_2	70	50	50	60	50	40	50	50	50	60

41

Data Sheet 17. Contact Resistance (ohms)

Limit: 0.5 ohms Maximum	Sample Number 102			Sample Number 104		
	Flow Gate Position			Flow Gate Position		
	Open	Closed		Open	Closed	
	B to D	A to C	B to E	B to D	A to C	B to E
Pretest Functional				0.301	0.304	0.311
High Temperature Functional	0.326	0.318	0.325	0.321	0.319	0.324
Post High Temperature Functional	0.308	0.297	0.305	0.388	0.307	0.319
Post Humidity Functional	0.317	0.303	0.367			
Post Salt Spray Functional	0.321	0.296	0.339			
Post Storage Functional	0.356	0.303	0.375			
Post Y-Axis Sweep Functional	-	-	-	0.314	0.315	0.317
Post Y-Axis Dwell Functional	-	-	-	0.320	0.317	0.315
Post Z-Axis Sweep Functional	-	-	-	0.313	0.313	0.315
Post Z-Axis Dwell Functional	-	-	-	0.317	0.315	0.316
Post X-Axis Sweep Functional	0.334	0.310	0.372	0.316	0.319	0.316
Post X-Axis Dwell Functional	0.344	0.315	0.333	0.316	0.317	0.316
Post Shock Functional	0.337	0.300	0.332	0.297	0.319	0.292
Post 400 Cycles @ Ambient	0.335	0.298	0.354	0.312	0.318	0.314
Post 200 Cycles @ + 130° F	0.329	0.301	0.343	0.305	0.316	0.327
Post 300 Cycles with 90 psig LN_2	0.341	0.297	0.332	0.325	0.320	0.311
Post 100 Cycles with 150 psig LN_2	0.310	0.293	0.329	0.324	0.329	0.316

Data Sheet 18. Humidity Test Insulation Resistance

Limit: 50 Megohms Minimum

			Terminal To Valve Body					Terminal To Terminal				
								Valve Closed			Valve Open	
Date	Time	Environmental Conditions	A	B	C	D	E	B to C	D to E	C to D	A to C	B to E
11-2-64	1230	130°F & 95% R. H.	500	300	500	780	300	300	400	450	900	650
11-3-64	0900	95°F & 95% R. H.	1500	900	1400	1800	1000	1300	1800	1800	3000	1000
11-3-64	1400	130°F & 95% R. H.	200	190	200	300	190	175	180	190	400	350
11-4-64	1200	130°F & 95% R. H.	225	150	225	350	200	200	175	200	300	350
11-4-64	1515	130°F & 95% R. H.	200	200	210	350	200	175	300	300	400	300
11-5-64	0800	85°F & 95% R. H.	1600	1400	1600	2000	1400	1500	1400	1500	1500	3000
11-6-64	0830	90°F & 95% R. H.	1000	800	900	1500	900	900	800	900	900	1500
11-6-64	1430	130°F & 95% R. H.	175	175	175	250	175	150	175	140	225	150
11-9-64	1500	130°F & 95% R. H.	125	140	140	200	150	130	200	200	250	125
11-10-64	0830	90°F & 95% R. H.	195	180	190	300	180	150	250	250	300	170
11-10-64	1400	130°F & 95% R. H.	200	195	190	300	200	170	250	250	200	250
11-11-64	1530	130°F & 95% R. H.	200	175	200	300	200	175	250	300	350	175
11-12-64	0830	90°F & 95% R. H.	1000	900	1000	1500	900	900	1300	1400	1800	1500
11-12-64	1400	130°F & 95% R. H.	200	200	220	350	200	175	200	200	250	400
11-13-64	0830	90°F & 95% R. H.	1000	900	850	1400	900	850	1200	1300	1700	750
11-13-64	1300	130°F & 95% R. H.	200	200	200	275	175	175	175	200	300	200

43

Data Sheet 19. Humidity Test Contact Resistance

Date	Time	Environmental Conditions	Flow Gate Position		
			Open	Closed	
			B to D	A to C	B to E
11-2-64	1230	130°F & 95% R. H.	0.3370	0.3285	0.3334
11-3-64	0900	95°F & 95% R. H.	0.3396	0.3226	0.3289
11-3-64	1400	130°F & 95% R. H.	0.3416	0.3276	0.3315
11-4-64	1200	130°F & 95% R. H.	0.3466	0.3279	0.3307
11-4-64	1515	130°F & 95% R. H.	0.3421	0.3275	0.3324
11-5-64	0800	85°F & 95% R. H.	0.3397	0.3199	0.3257
11-6-64	0830	90°F & 95% R. H.	0.3438	0.3215	0.3273
11-6-64	1430	130°F & 95% R. H.	0.3424	0.3271	0.3317
11-9-64	1500	130°F & 95% R. H.	0.3404	0.3268	0.3321
11-10-64	0830	90°F & 95% R. H.	0.3431	0.3278	0.3320
11-10-64	1400	130°F & 95% R. H.	0.3404	0.3268	0.3314
11-11-64	1530	130°F & 95% R. H.	0.3432	0.3275	0.3316
11-12-64	0830	90°F & 95% R. H.	0.3411	0.3220	0.3271
11-12-64	1400	130°F & 95% R. H.	0.3443	0.3273	0.3324
11-13-64	0830	90°F & 95% R. H.	0.3417	0.3213	0.3269
11-13-64	1300	130°F & 95% R. H.	0.3443	0.3267	0.3328

44

APPENDIX C

Illustrations

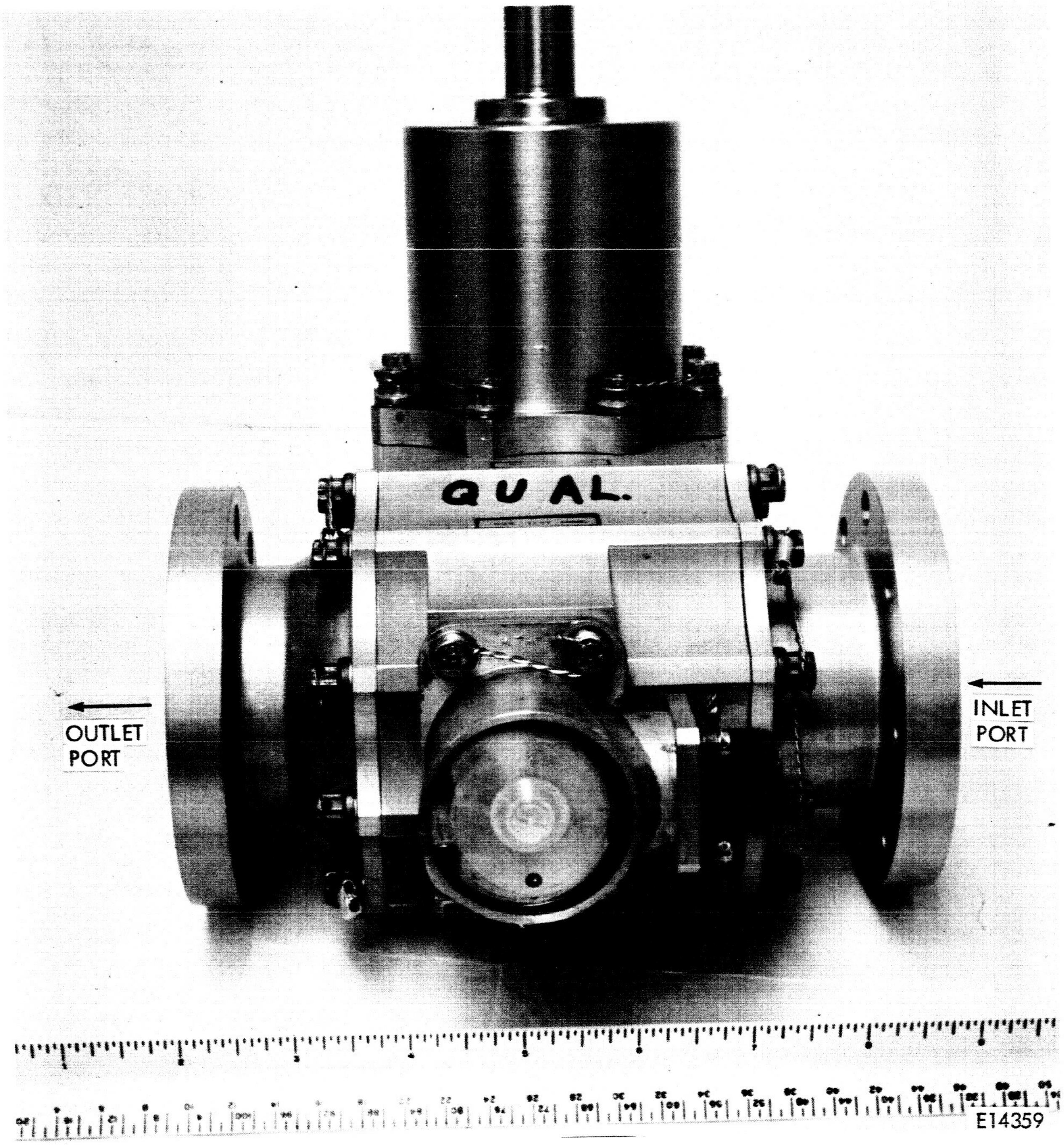


Figure 1. LOX Replenishing Valve

N/A

Figure 2. Control Piston Showing Aluminum Chips from Internal Chafing by the Spring

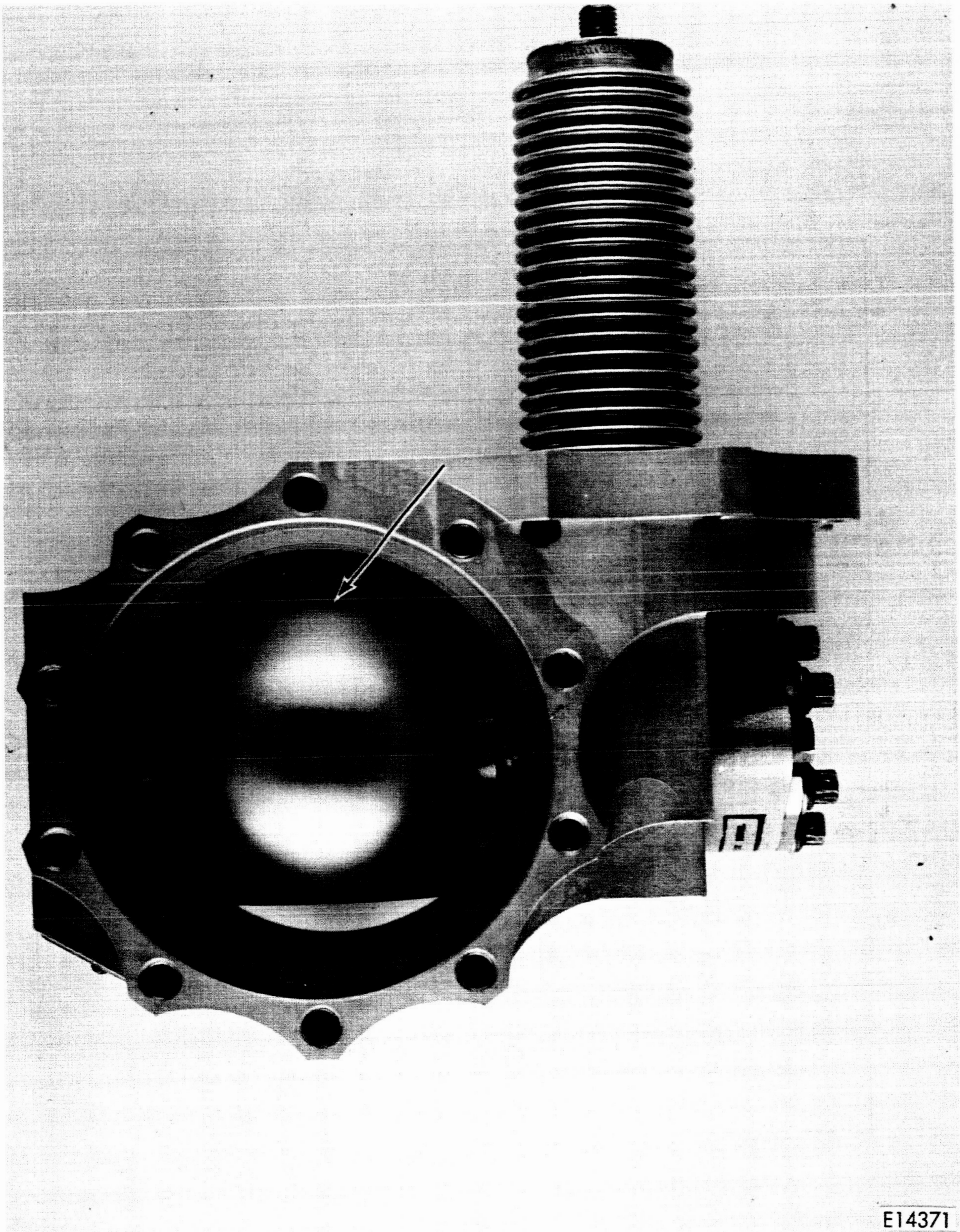


Figure 3. Flow Control Gate Showing Scratch Mark

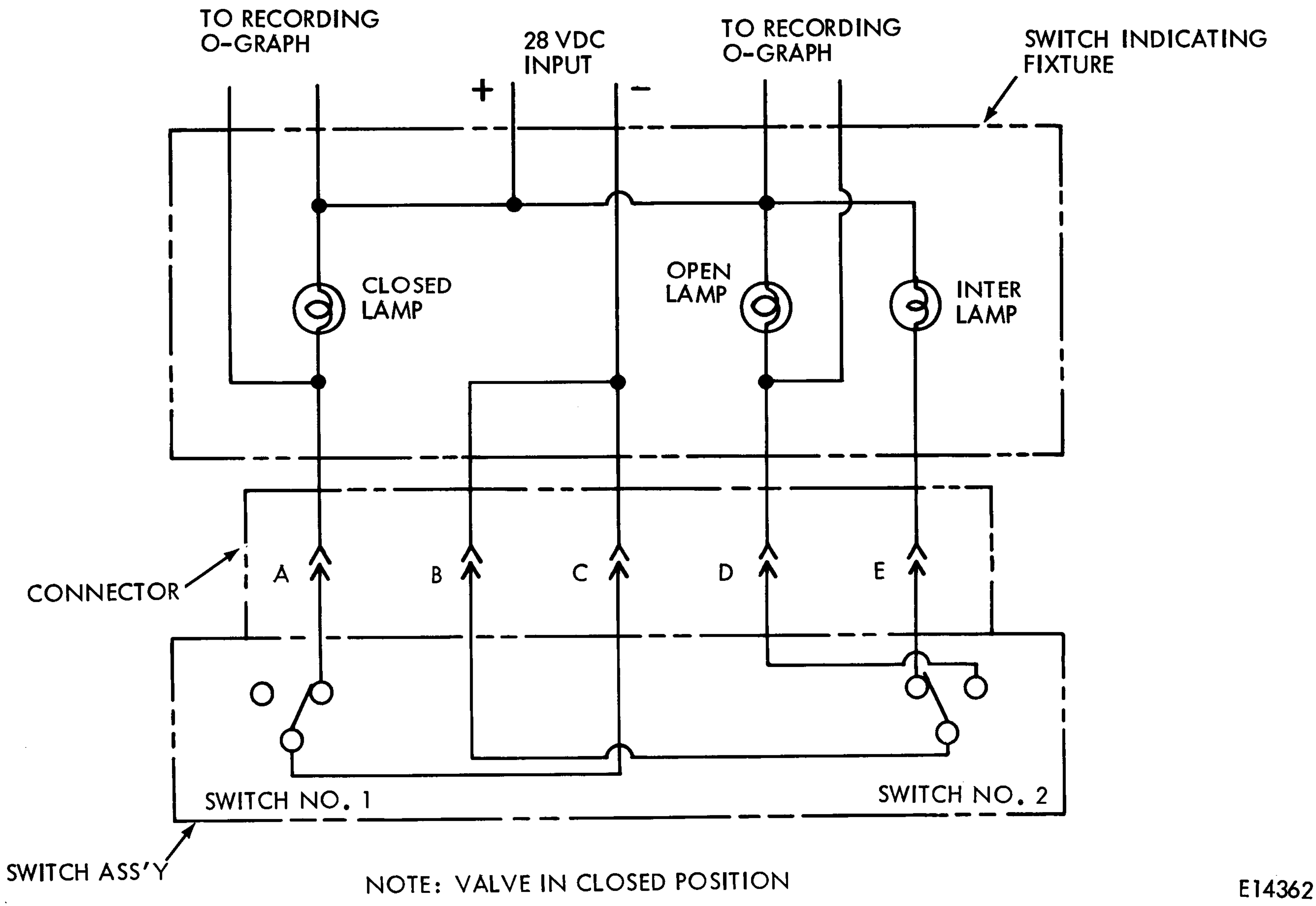


Figure 4. Position Indication Schematic

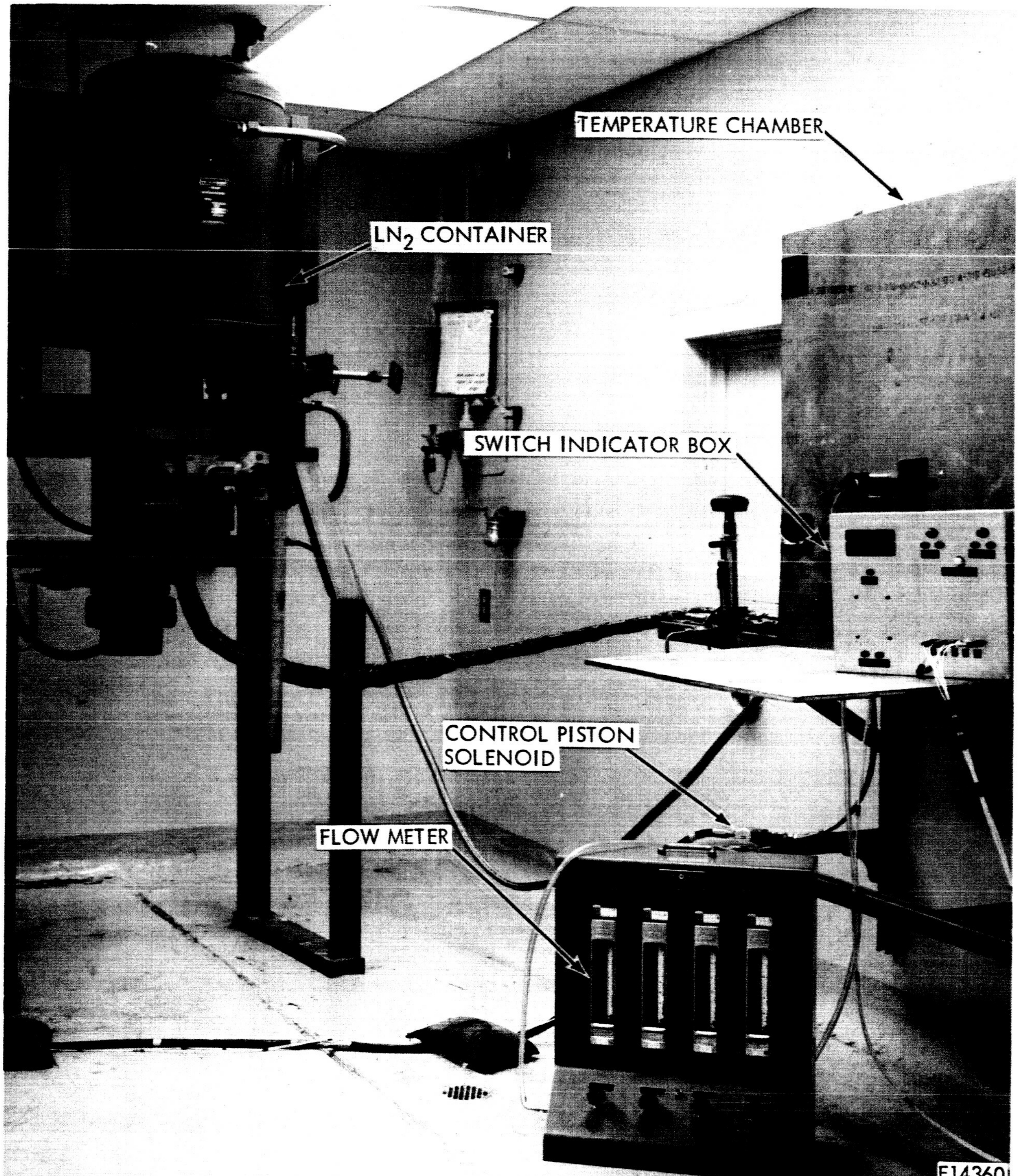


Figure 5. Functional Test Setup

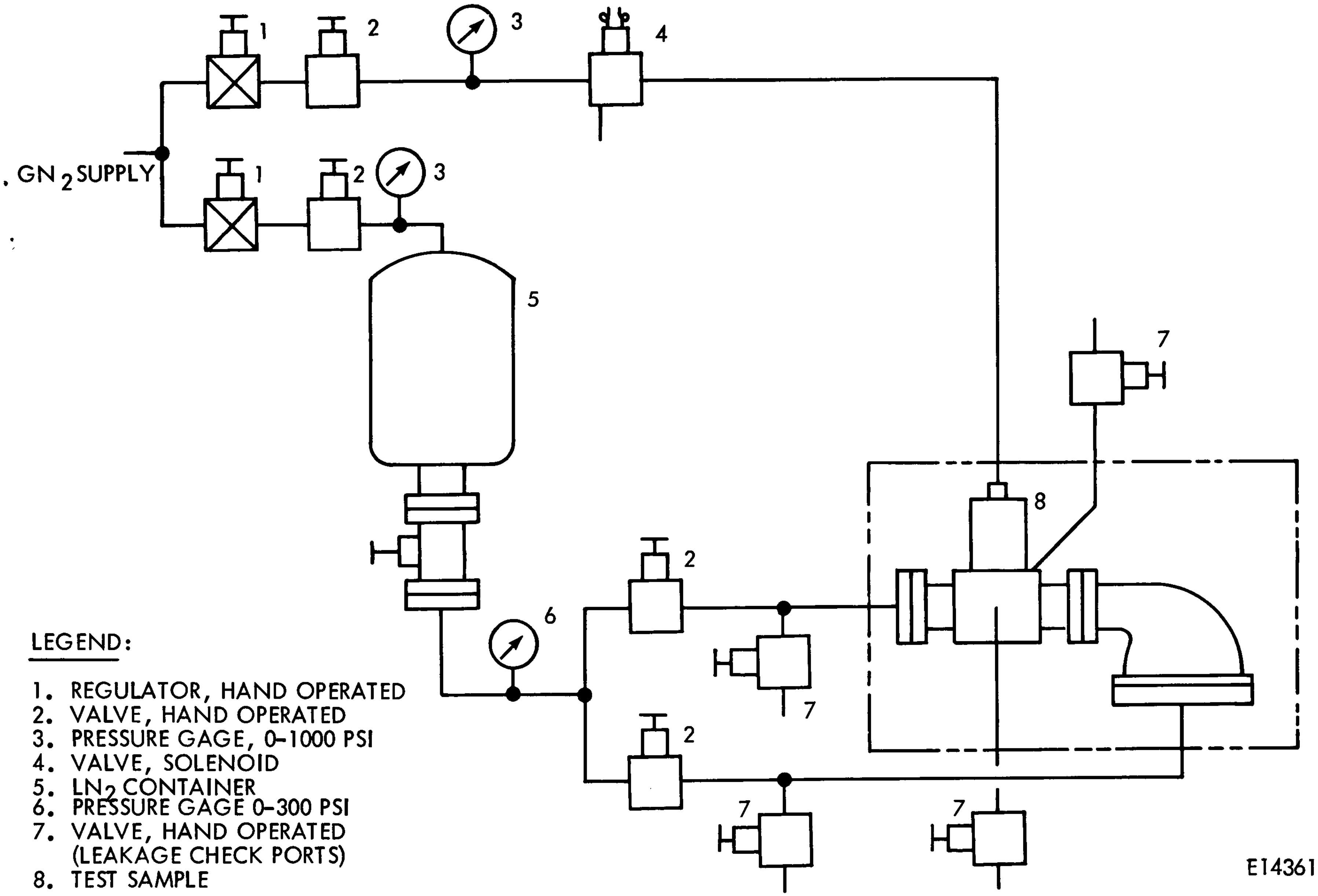


Figure 6. Functional Test Schematic

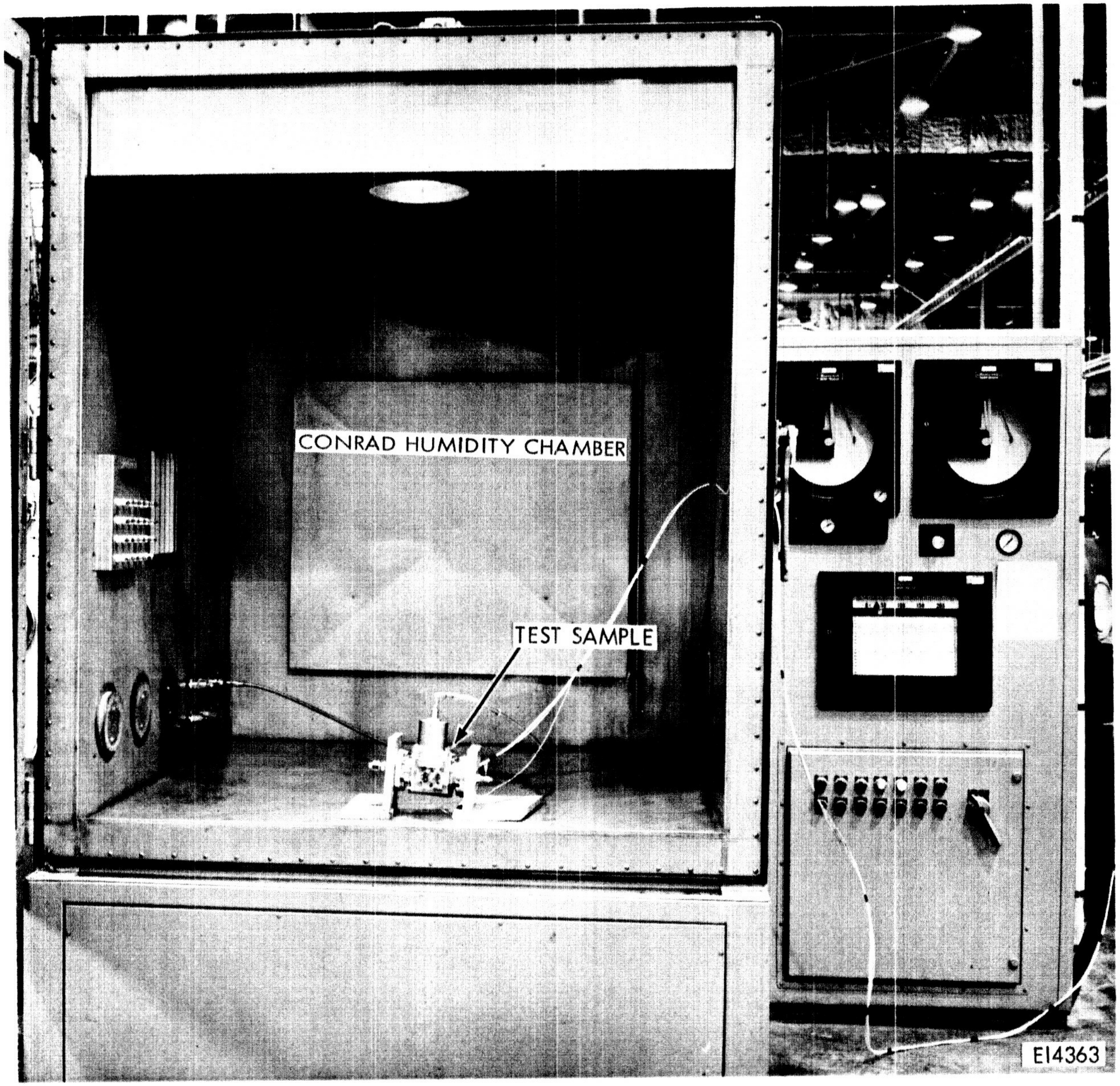


Figure 7. Humidity Test Setup

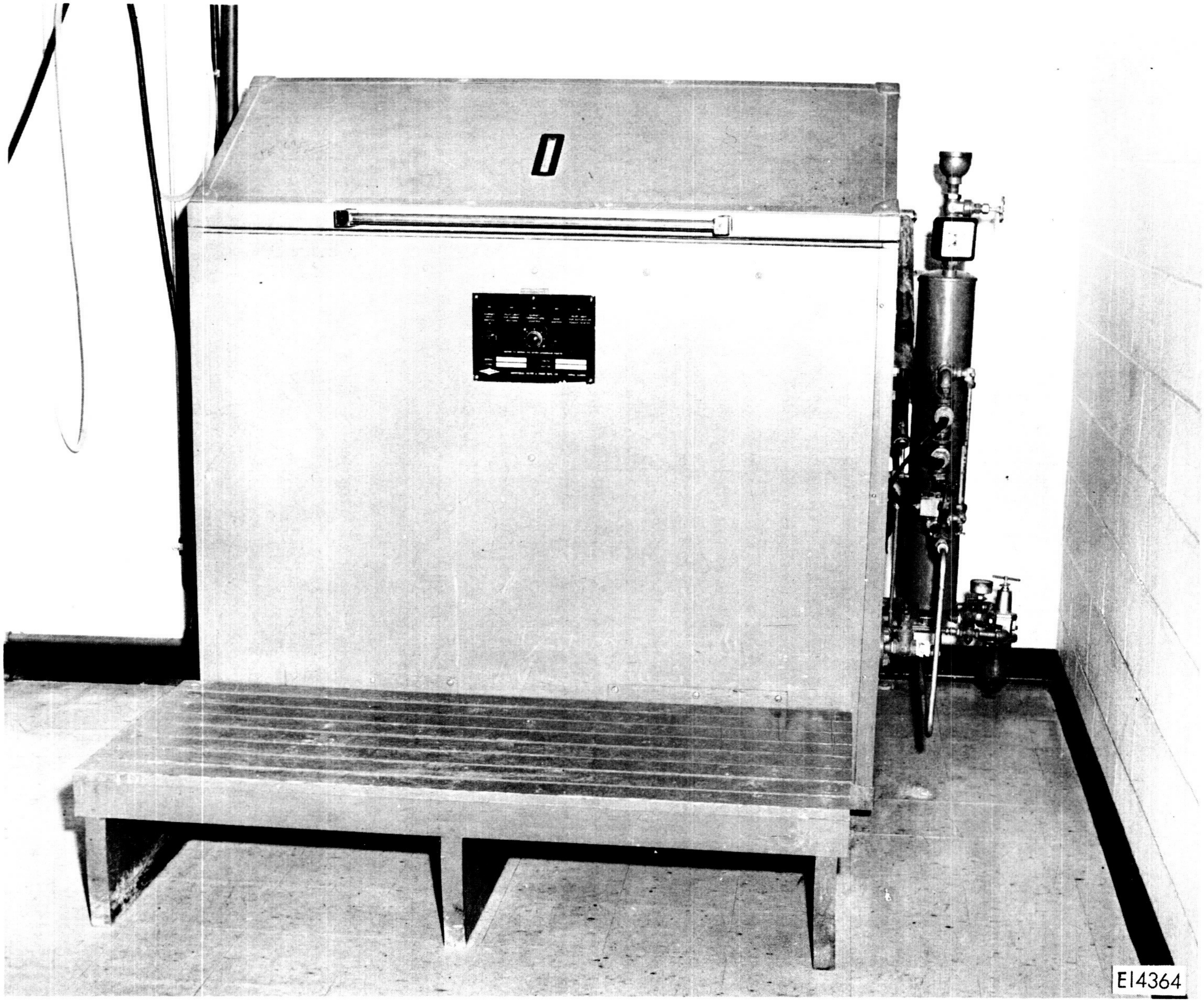


Figure 8. Salt Spray Chamber

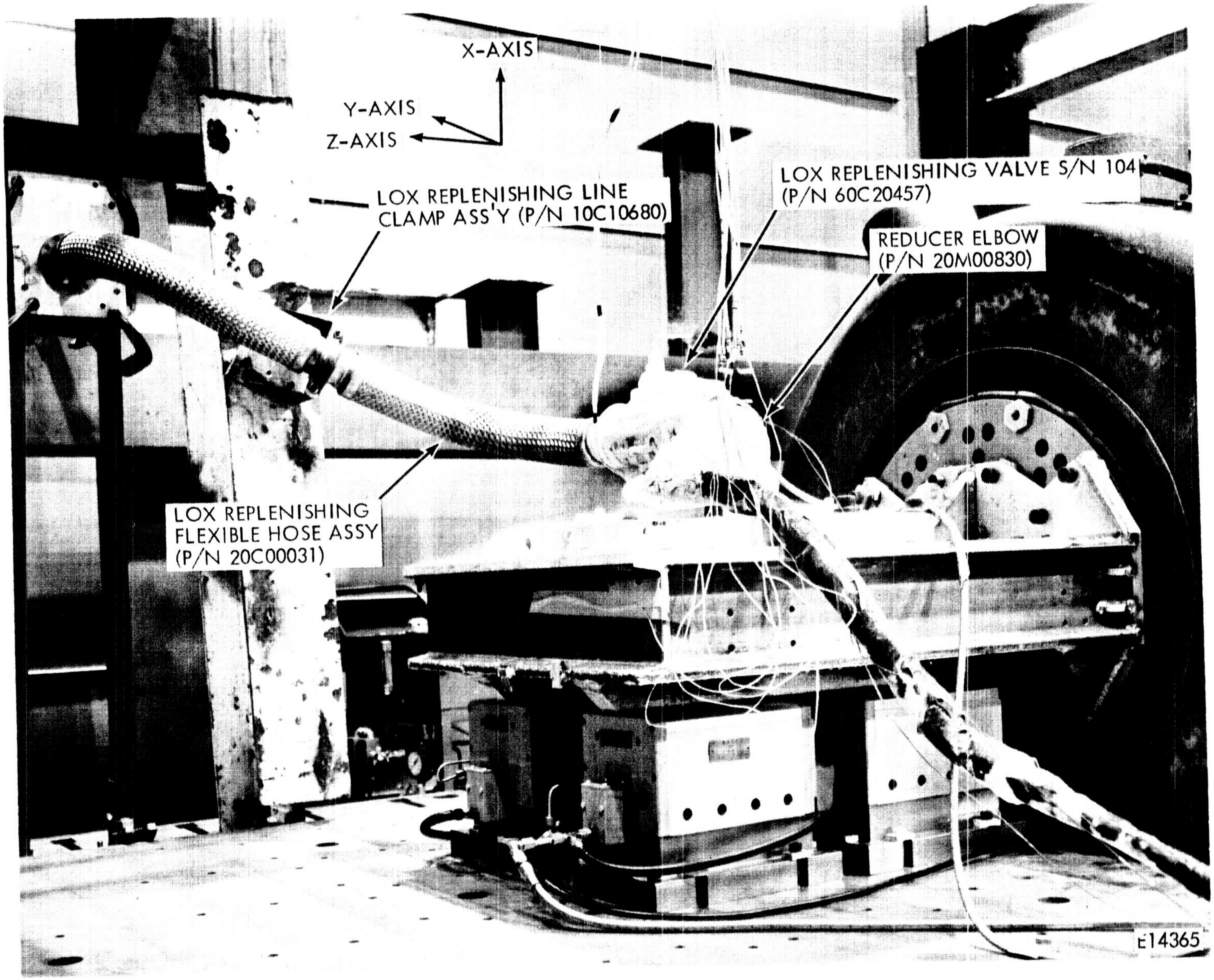


Figure 9. Vibration Test Setup for Z-Axis

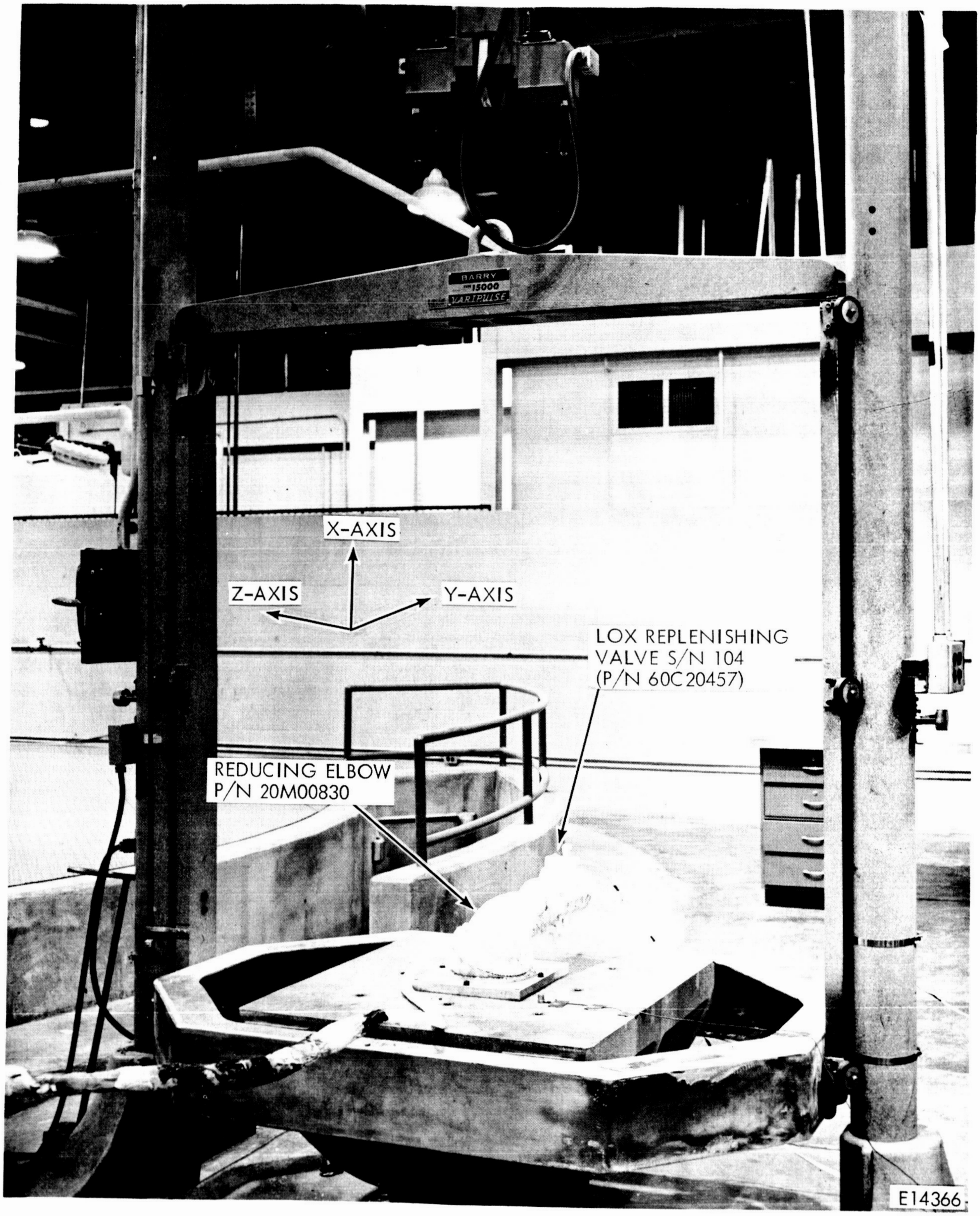


Figure 10. Impact Shock Setup for X-Axis

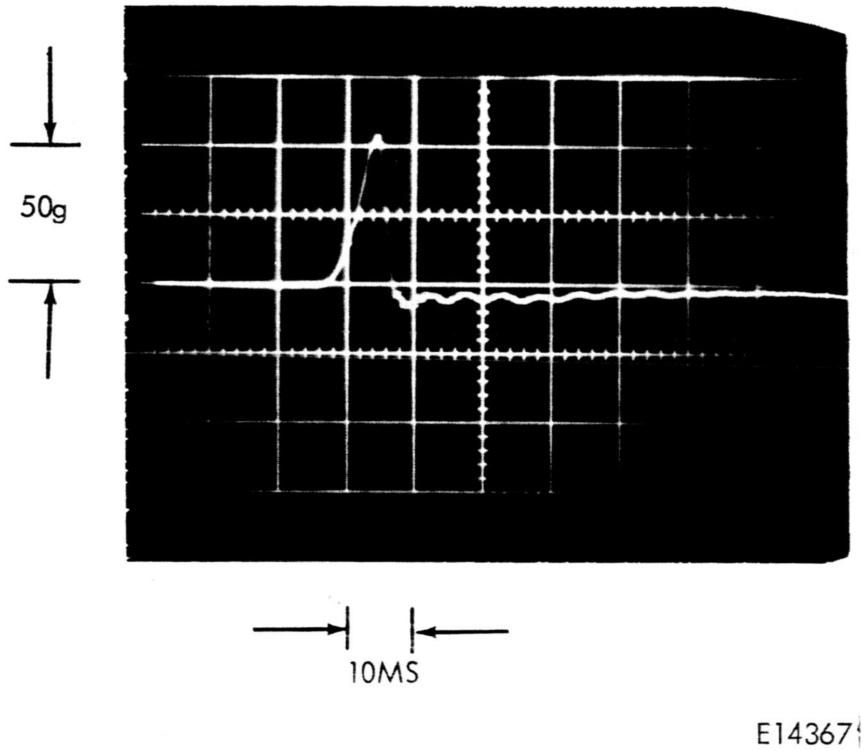


Figure 11. Typical Impact Shock Waveform

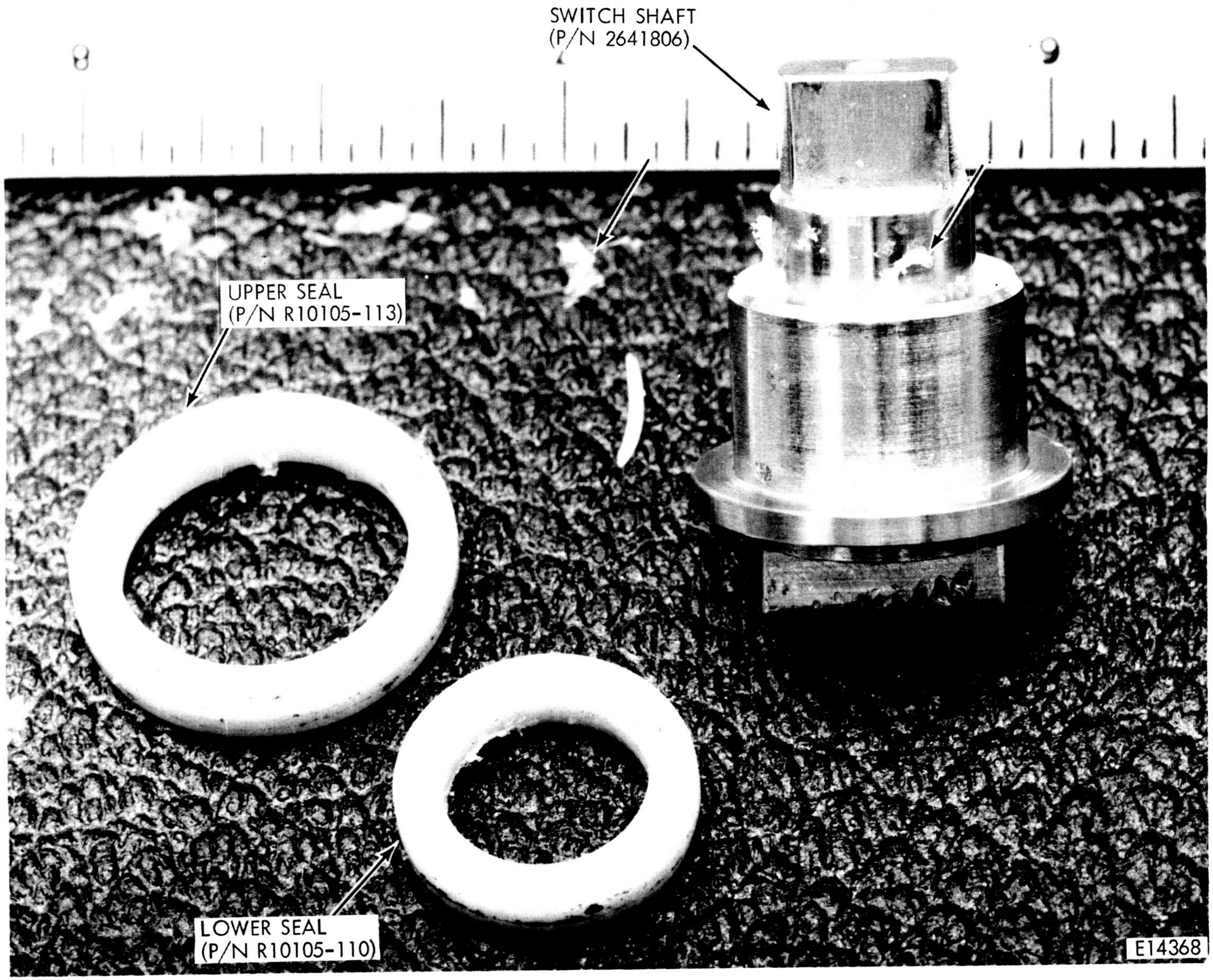


Figure 12. Switch Shaft and Seals (Sample 102)

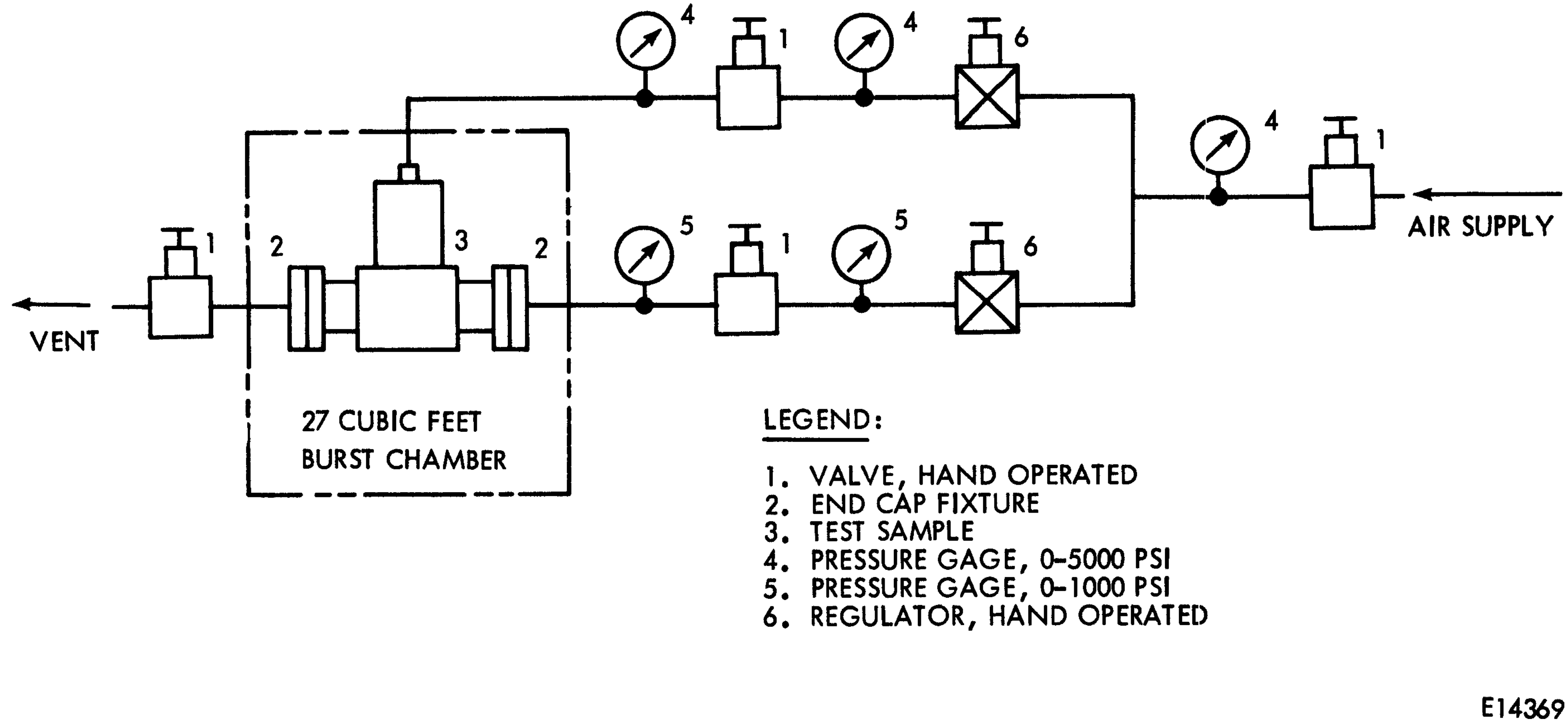


Figure 13. Proof Pressure and Burst Test Schematic

APPENDIX D

Technical Procedure
TP-RE-64-43

QUALIFICATION TEST

OF

SATURN S-IB STAGE

LOX REPLENISHING VALVE

(60C20457)

1 INTRODUCTION

1.1 Objective. The purpose of this test program is to determine whether the LOX Replenishing Valve will meet the qualification requirements of Specification 60C26012.

1.2 Description. The LOX Replenishing Valve is a normally closed (NC) ball type valve. It is closed by a loaded spring and opened by a pneumatic control piston assembly. One LOX Replenishing Valve is used to make final weight adjustments, according to fuel density changes, by adding or draining LOX from the LOX tanks. It is located near the bottom of LOX Tank 0-4 at station 207. The LOX Replenishing Valve measures 7 by 8.5 by 9 inches and weighs 10 pounds. It is made by Parker Aircraft Co. (Vendor Part No. 2630287).

1.3 Test Samples. Two LOX Replenishing Valves will be provided by CCSD Propulsion and Vehicle Engineering Branch and will be tested for qualification as specified in this procedure.

45

2 APPLICABLE DOCUMENTS

The following documents contain the environmental requirements for qualification of the Saturn S-IB Stage mechanical components:

2.1 <u>NASA - MSFC Specifications</u>

MSFC-SPEC-106	Testing of Compatibility of Materials for Liquid Oxygen Systems, Specifications for
MSFC-SPEC-164	Cleanliness of Components for Use in Liquid Oxygen, Fuel, and Pneumatic Systems, Specification for
60C26012	Valve Assembly, LOX Replenishing, Specification for

2.2 <u>Military Specifications</u>

MIL-E-5272C	Environmental Testing, Aeronautical and Associated Equipment, General Specification for

2.3 <u>Standards</u>

Federal Test Method Standard	Metals; Test Methods Number 151a.

3 TEST TOLERANCES

3.1 Environmental Tolerances. The maximum allowable deviations from the environmental conditions specified in this procedure are as follows:

a.	Temperature	± 5°F
b.	Relative Humidity	± 5%
c.	Vibration	+5, -0% amplitude
d.	Impact Shock	± 10% pulse duration

3.2 Measurement Tolerances. Unless otherwise specified, the maximum allowable error in measurement instruments are as follows:

a.	Temperature	± 2.5°F
b.	Pressure	± 2.5%
c.	Relative Humidity	± 2.5%
d.	Vibration	±2.5% amplitude ± 2.5% frequency
e.	Impact Shock	±2.5% amplitude ±2.5% pulse duration

3.3 Ambient Conditions. Room ambient conditions shall be kept within the following specified limits:

a.	Temperature	77°F(± 18°F)
b.	Relative Humidity	20 to 95%
c.	Pressure	24 to 32 in. Hg

4 TEST EQUIPMENT

4.1 Laboratory Equipment. The tests require the following laboratory equipment:

a.	Pressure Regulator	Grove, Model 18
b.	Pressure Gage	Heise D, 1000 psig
c.	Solenoid Valve	Marotta MV-74
d.	Flowmeter	Porter, 10A2700C
e.	Metering Valve	Robbins, 1/4-inch
f.	Timer	Beckman, 7370N

4.2 Laboratory Facilities. The following facilities are required for the environmental tests:

a.	Environmental Chamber	Conrad, -100°F to +300°F
b.	Humidity Chamber	20 to 95% RH
c.	Vibration System	MB, C-210 20 to 2000 cps
d.	Shock Machine	Barry, Model 1500 7500 force pounds
e.	Burst Chamber	27 cubic feet

4.3 Special Equipment. The following special test equipment is required:

a.	Test Fixtures	To be fabricated
b.	Elbow	P/N 20M00830
c.	Hose Assembly	P/N 20M00031

5 TEST DEFINITIONS AND REQUIREMENTS

5.1 Definitions

5.1.1 Failure. Any result that does not meet the requirements of the functional and operational tests shall be considered a failure. A failure that does not effect the operation of the sample in its intended use shall not be cause for discontinuance of testing. However, the responsible engineer shall determine the cause of each failure and shall inform the Design Engineering Unit so that failure resolution and coordination can be made.

5.1.2 Temperature Stabilization. Stabilization is defined as a change of not more than 2°F in the temperature of the test sample over a period of 15 minutes when temperature readings are taken every 5 minutes.

5.1.3 Major Resonance. A major resonance is defined as a resonance point having a transmissibility ratio of 2 : 1 or greater.

5.2 Pretest Requirements

5.2.1 Inspection. Before starting the qualification tests, each sample shall be inspected by the engineering laboratory for conformance to Specification 60C26012. Each sample shall be visually examined for defects and damage during and after testing. Unless otherwise specified, inspection shall not include disassembly of the sample before testing.

5.2.2 Proof-Pressure Test. Before starting the qualification tests, each sample shall be subjected to the proof-pressure tests specified in 5.2.2.1 and 5.2.2.2 (see figure 1).

5.2.2.1 Flow Chamber. The outlet port of the flow chamber shall be pressurized with air to 225 psig. The pressure shall be held for five minutes while the flow control gate is fully opened and the inlet port is capped. While maintaining a 225-psig pressure at the outlet port, the gate shall be closed and the inlet port shall be vented. The pressure shall be maintained at the outlet port for an additonal five minutes.

5.2.2.2 Control Piston Assembly. The control port shall be pressurized with air to 1,125 psig. The pressure shall be held for five minutes.

5.3 Test Sequence. The sequence of qualification tests for each sample shall be as follows:

17

Test	Sample No. 1	Sample No. 2	Reference (Paragraph)
Functional	X	X	5.4
Dielectric Strength	X	X	6.1
High Temperature	X	X	6.2
Humidity	X		6.3
Salt Spray	X		6.4
Vibration	X	X	6.5
Shock	X	X	6.6
Life Cycle	X	X	6.7
Burst Pressure	X	X	6.8

5.3.1 Test Schedule. The testing schedule for span of time shall be as shown in figure 2.

5.3.2 Test Limits. The limits of the test environments shall be as outlined in table 1.

Table 1. Limits of Test Environments

Item No.	Environment	Qualification Test Limits
1	Dielectric Strength	1000V AC
2	High Temperature	130°F
3	Humidity	MIL-E-5272C
4	Salt Spray	MIL-E-5272C
5	Vibration	20-2000 cps 30g
6	Shock	50g
7	Life Cycle	1000 cycles
8	Burst	---
9	Flow Chamber	375 psig
10	Control Piston	1,875 psig

5.4 Functional Test. Before conducting any qualification tests, the test sample shall be subjected to a comprehensive functional test (see figure 3) as specified in 5.4.1 through 5.4.5. A record shall be made of all data to determine compliance with applicable specifications and to provide criteria for verifying the satisfactory performance of the test sample during and after qualification testing. The functional test shall be performed at the stabilized temperature specified in the individual test. The service media shall be:

a. Air, helium, or gaseous nitrogen for the control piston assembly.

b. Liquid oxygen, liquid nitrogen, and air for the flow chamber.

5.4.1 Valve Operation. While a 90-psig (± 2 psig) LN_2 pressure is applied to the outlet port of the flow chamber, the valve gate shall be actuated a minimum of five times from the fully open to the fully closed position by applying a pneumatic pressure of 750 psig (± 10 psig) to the control piston. The valve assembly operation shall conform to 5.4.1.1 and 5.4.1.2. No damage or impairment of performance shall be allowed.

5.4.1.1 Position Indicators

5.4.1.1.1 Closed Position Switch. The closed position switch shall operate as follows:

a. Actuate (establish continuity between terminal pins A and C) at 5 degrees (±2 degrees) from the fully closed position as the gate moves toward the closed position.

b. Deactuate (lose continuity between terminal pins A and C) at 12 degrees maximum from the fully closed position as the gate leaves the closed position.

c. No continuity between terminal pins A and C when the flow control gate is between the deactuation position (see b) and fully open position, and between the fully open position and the actuation position (see a).

5.4.1.1.2 Open Position Switch. The open position switch shall operate as follows:

a. Lose continuity between terminal pins B and E and gain continutiy between pins B and D at 5 degrees (± 2 degrees) from the fully open position as the flow control gate moves toward the open position.

b. Gain continuity between terminal pins B and E and lose continuity between pins B and D at 12 degrees maximum from the fully open position as the flow control gate leaves the open position.

c. Continuity between terminal pins B and E, and no continuity between pins B and D when the flow control gate is between the position described in b and the fully closed position; and between the fully closed position and the position described in a.

5.4.1.2 Operating Time. The operating time of the flow chamber gate while at LN_2 temperature shall not be greater than 1000 milliseconds from the fully open position to the fully closed position or vice versa. The position switches shall be used to start and stop the timer.

5.4.2 Leakage of Liquid Nitrogen

5.4.2.1 Inlet Port. With the flow control gate closed, the inlet port of the flow chamber shall be pressurized to 50 psig ($\pm$ 1 psig) with LN_2. There shall be no liquid leakage externally or past the gate seal. There shall be no liquid leakage into the switch housing past the shaft seals.

5.4.2.2 Outlet Port. With the flow control gate closed, the outlet port of the flow chamber shall be pressurized to 150 psig with LN_2. There shall be no leakage externally or past the gate seal.

5.4.2.3 Both Ports. The entire flow chamber shall be slowly pressurized from zero to 150 psig with LN_2. While the pressure is being applied, the valve shall be continuously inspected for conformance to the following requirements:

a. Shaft Seal - Zero liquid leakage and 10.0 scim maximum gaseous leakage.

b. External - Zero liquid and gaseous external leakage.

c. Bellows and Bellows Seals - Zero liquid and gaseous leakage.

5.4.3 Control Piston Assembly

5.4.3.1 Operating Pressure. The outlet port of the flow chamber shall be pressurized to 90 psig with LN_2. Connect a normally closed solenoid valve to the opening port of the control piston. Apply pressure upstream to the solenoid valve in 5 psig increments and actuate the solenoid after each increase until the flow gate is fully open. The maximum allowable pressure to fully open the flow gate shall be 500 psig. This test shall be repeated three times.

5.4.3.2 Leakage. The outlet port of the flow chamber shall be pressurized to 90 psig ($\pm$ 2 psig) with LN_2. Then, the control piston assembly shall be slowly pressurized to 750 psig ($\pm$ 10 psig) with GN_2. The valve shall be inspected for conformance to the following requirements:

a. Bellows and Bellows seals - Zero allowable leakage.

b. External - Zero allowable external leakage.

5.4.4 Flow Chamber Leakage

5.4.4.1 Inlet Port. With the flow control gate closed, the inlet port of the flow chamber shall be pressurized to 50 psig (± 1 psig) pneumatic pressure. The gas leakage past the gate seal shall not be greater than 40 scim. The gas leakage past the shaft lip seal into the switch housing shall not exceed 10 scim. There shall be no external gas leakage.

5.4.4.2 Outlet Port. With the flow control gate closed, the outlet port of the flow chamber shall be pressurized to 150 psig (±3 psig) pneumatic pressure. The gas leakage past the gate seal shall not be greater than 40 scim.

5.4.5 Resistance

5.4.5.1 Insulation Resistance. The insulation resistance shall be measured for the conditions shown below with a 500V DC megger. The resistance shall not be less than 50 megohms with the valve assembly temperature stabilized with LN_2 in the flow chamber.

a. From each terminal pin of the electrical connector to the body of the valve assembly.

b. With the flow gate in the fully closed position, check as follows:

(1) Between terminal pins B and C

(2) Between terminal pins D and E

(3) Between terminal pins C and D

c. With the flow gate in the full open position, check as follows:

(1) Between terminal pins A and C

(2) Between terminal pins B and E

5.4.5.2 Contact Resistance. The resistance of the fully closed switches shall be measured as specified in 5.4.5.2.1 and 5.4.5.2.2. The resistance shall not be greater than 0.5 ohms.

5.4.5.2.1 Valve Open. The flow control gate shall be moved to the fully open position by applying 750 psig (±10 psig) GN_2 to the opening control port of the control piston assembly. Contact resistance between pins B and D of the electrical connector shall be checked.

5.4.5.2.2 Valve Closed. The flow control gate shall be moved to the fully closed position, and the contact resistance between pins A and C and between B and E of the electrical connector shall be measured.

6 QUALIFICATION TESTS

6.1 Dielectric Strength. Perform this test only once during this test program. Apply 1000V RMS, 60 cps potential as follows:

a. From each terminal pin of the electrical connector to the body of the valve assembly for 60 seconds.

b. With the flow control gate in the fully closed position, check the following for 60 seconds each:

(1) Between terminal pins B and C

(2) Between terminal pins D and E

(3) Between terminal pins C and D

c. With the flow control gate in the fully open position check the following for 60 seconds each:

(1) Between terminal pins A and C

(2) Between terminal pins B and E

6.2 High Temperature. Place the test sample in a temperature chamber and connect all necessary instrumentation and functional equipment as shown in figure 3. Position the sample in an attitude similar to flight conditions and consistent with good testing practices. Raise the temperature of the chamber to 130°F and maintain the temperature for 24 hours.

After 24 hours, and while the valve is at 130°F, test the valve as specified in 5.4 with the exception of 5.4.2. GN_2 shall be substituted for all tests requiring LN_2 as a pressurizing media.

Return the valve to ambient conditions and test it as specified in 5.4.

6.3 Humidity. Place the valve in a humidity chamber and position it in a flight direction. Cap the inlet and outlet ports and attach all electrical connectors to simulate actual flight conditions. Vent the chamber to the atmosphere to prevent pressure buildup. Prior to testing, the temperature of the chamber shall be between 68 and 100°F with uncontrolled humidity. During the first two-hour period, gradually raise the temperature to 130°F and maintain this temperature for six hours. During the following 16-hour period, gradually reduce the temperature in the chamber to between 68 and 100°F. This 24-hour period constitutes one cycle. Repeat this cycle 10 times while the relative humidity is maintained at 95 percent.

The velocity of the air in the chamber shall not exceed 150 feet per minute. Steam or distilled water, having a pH value between 6.5 and 7.5 at 77°F, shall be used to obtain the desired humidity. During this test, the valve assembly shall be tested a minimum of once in every 24 hour period as specified in 5.4.5.1 and 5.4.5.2. At the end of the humidity test, return the valve assembly to ambient conditions. Wipe the valve dry and, within one hour after its removal from the chamber, perform a complete functional test as specified in 5.4.

6.4 Salt Spray. After capping all ports and attaching all electrical connectors to simulate flight conditions, place the valve assembly in a salt spray chamber.

The valve assembly shall be exposed to salt spray for 24 hours as specified in Method 811.1 of Federal Test Method Standard No. 151a. At the completion of the 24-hour period, remove the valve assembly from the salt spray chamber and rinse the valve with tap water. Within one hour, the valve assembly shall be given a functional test as specified in 5.4. It shall be stored for 48 hours and then retested as specified in 5.4. There shall be no deterioration or change in performance.

6.5 Vibration. Install the valve assembly along with the reducing elbow (the S-IB equivalent of drawing 20M00830), the flex hose (the S-IB equivalent of drawing 20M00031), and the associated hardware, in a test setup that simulates vehicle installation (the S-IB equivalents of drawings 10M10003 and 10M10008). Rigidly support the vehicle bracket which supports the center of the flex hose. Flow liquid nitrogen through the valve assembly until the the valve's temperature stabilizes. Maintain the valve assembly at this stabilized temperature for the duration of the test. Monitor the position indicating switches throughout the test for erroneous indications or contact chatter. Vibrate the valve assembly as specified in 6.6.1 and 6.5.2. Apply vibration input to the reducing elbow.

6.5.1 Sweep Test. Scan the frequency range 20 cps to 2,000 cps (6-2/3 octaves) logarithmically at the rate of 0.67-octave/minute along each of the sample's major axes (see figure 5) at the following input levels:

20 to 28 cps at 0.2-inch DA displacement

28 to 72 cps at 8.0g peak

72 to 140 cps at 0.03-inch DA displacement

140 to 2000 cps at 30.0g peak

During the vibration test, pressurize the outlet port to 90 psig with LN_2 while the flow control gate is closed. There shall be no leakage externally past the gate seal. The frequencies of resonance shall be recorded. At the completion of the sweep test, the valve shall be tested as specified in 5.4.

6.5.2 Resonance Test. Subject the valve assembly to five minutes of vibration at the major resonant frequencies noted during the sweep test (see 6.5.1).

55

A maximum of two resonance frequencies per axis shall be used. The input levels at the respective frequencies are as follows:

20 to 28 cps at 0.1-inch DA displacement

28 to 72 cps at 4.0 g peak

72 to 140 cps at 0.015-inch DA displacement

140 to 2000 cps at 15.0 g peak

During the vibration test, pressurize the outlet port to 90 psig with LN_2 while the flow control gate is closed. There shall be no leakage externally or past the gate seal. At the completion of the resonance test the valve shall be tested as specified in 5.4.

Deviations of plus or minus 10 percent of the resonance test levels are allowable. During resonance testing, the test frequency shall be adjusted to account for any shifts in the resonant frequency of the valve assembly.

6.6 Shock. Attach the valve assembly and all associated flight brackets to a shock machine (see figure 6). Flow liquid nitrogen through the valve assembly until the valve temperature stabilizes. Maintain the valve assembly at this stabilized temperature for the duration of the test.

Subject the valve assembly to six shocks along each of the three major axes. Distribute the shock three times in each direction for each axis. Apply the shock input to the base of the elbow adapter as follows:

a. 50 g for 10 milliseconds duration (half-sine wave) or

b. 50 g for 8 milliseconds duration (sine wave) or

c. 50 g for 6 milliseconds duration (square wave)

Deviations from the specified level and rise time of ± 15 percent (including instrument error) are allowed. Permission to deviate from this criteria must be requested from the procuring activity.

During the shock test, pressurize the outlet port to 90 psig with LN_2 while the flow control gate is closed. Monitor the contacts of the position switches to determine whether any erroneous indications occur. There shall be no leakage externally or past the gate seal. At the completion of the shock tests the valve assembly shall be tested as specified in 5.4.

6.7 Life Cycle. Energize the position switches with 28V DC and load so there is a resistive current of 3.0 amperes when the contacts are closed. Subject the valve assembly to 1000 cycles of operation at approximately 6 seconds per cycle. The cycles shall be performed as follows:

a. 400 cycles with the valve assembly stabilized at standard temperature.

b. 200 cycles with the valve assembly stabilized at +130°F.

c. 300 cycles with the entire flow chamber pressurized to 90 psig with LN_2 (no flow).

d. 100 cycles with the outlet port (tank end) of the flow chamber pressurized to 150 psig with LN_2 (flow when gate is open).

The cycles shall be performed with 750 psig (± 10 psig) control pressure. After each temperature phase, the valve assembly shall be tested as specified in 5.4.

6.8 Burst Pressure. Place the valve assembly in a burst chamber and cap the inlet port. Pressurize the outlet port of the flow chamber to 375 psig. Maintain this pressure for three minutes while the flow control gate is closed; then, held for three more minutes while the gate is open. Vent the flow chamber and pressurize the control piston to 1,875 psig. Maintain this pressure for three minutes.

7 DATA HANDLING

7.1 Log Books. An individual log shall be kept on each test sample. The information recorded in the log book shall include, but not be limited to, part number, name, seriel number(s), dates and times of tests, notation of all failures, etc.

7.2 Charts and Graphs. All charts, graphs, and oscillograph recordings shall be identified by test sample name, part number, and serial number, dates and times of test, type of test, and scales used in plotting the information. All such records shall be kept with the log books.

7.3 Data Sheets. All information and data taken manually shall be recorded in the log book. A separate data sheet shall be used for each functional and operational test. All data must be signed by engineering personnel.

7.4 Final Report. The Test and Evaluation Section shall be responsible for the preparation of the final test report. The report shall include a complete record of all tests outlined in this procedure.

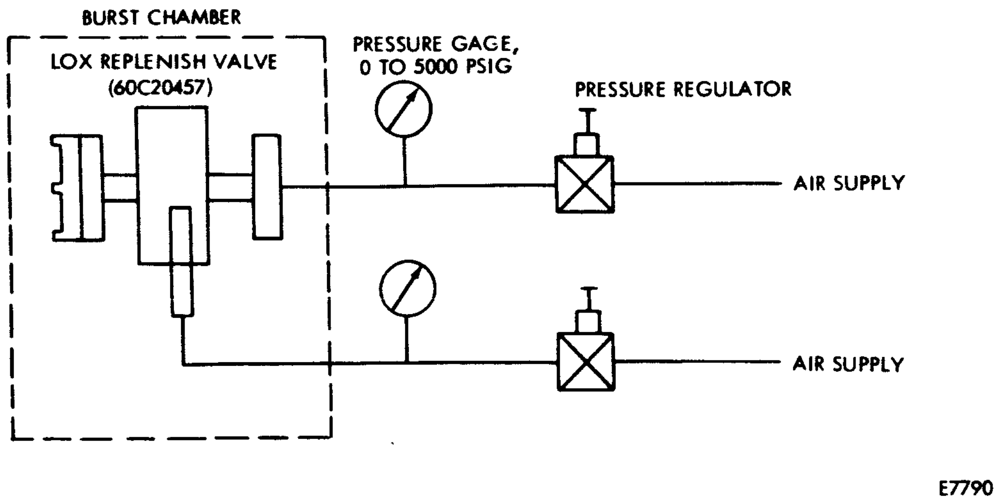
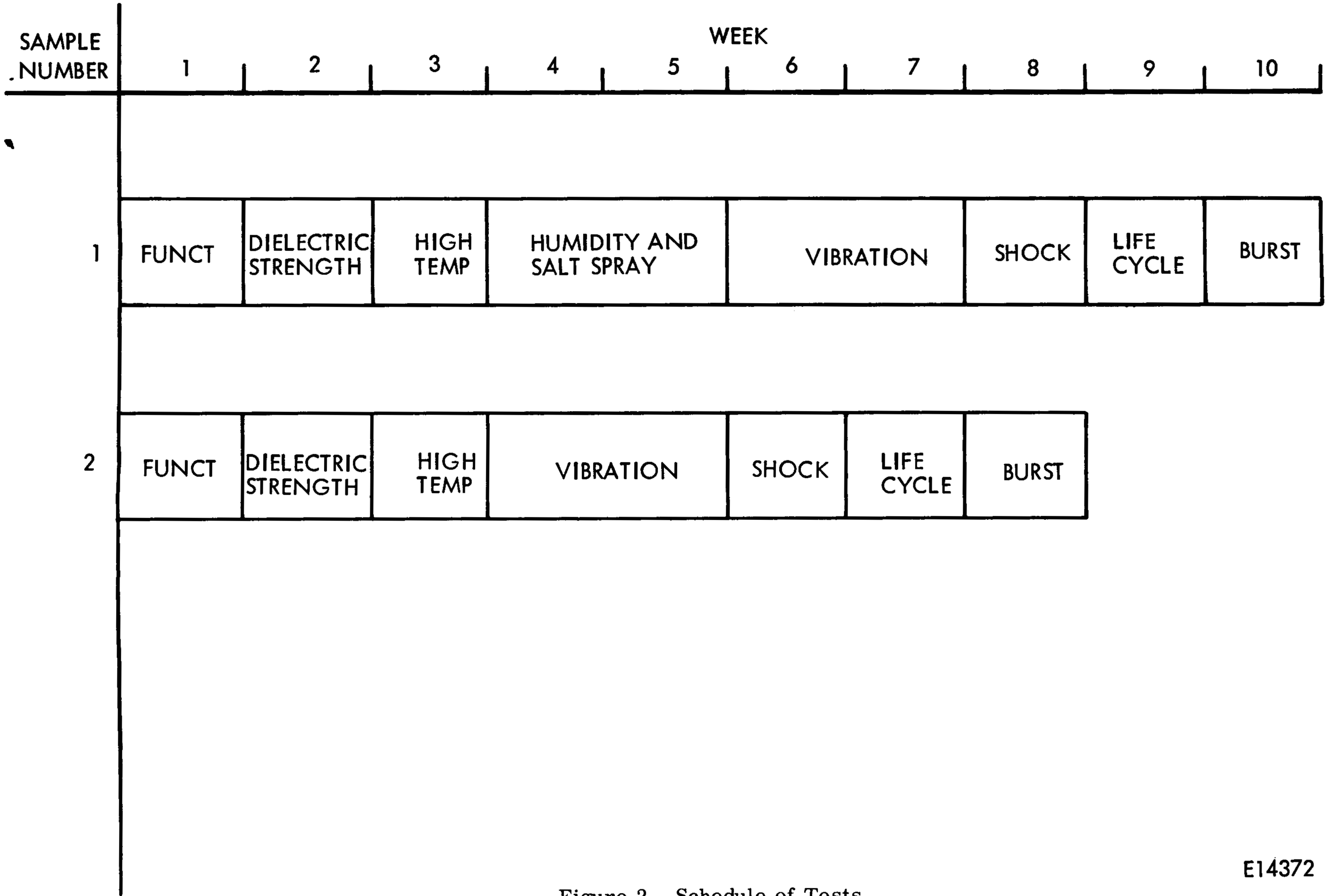


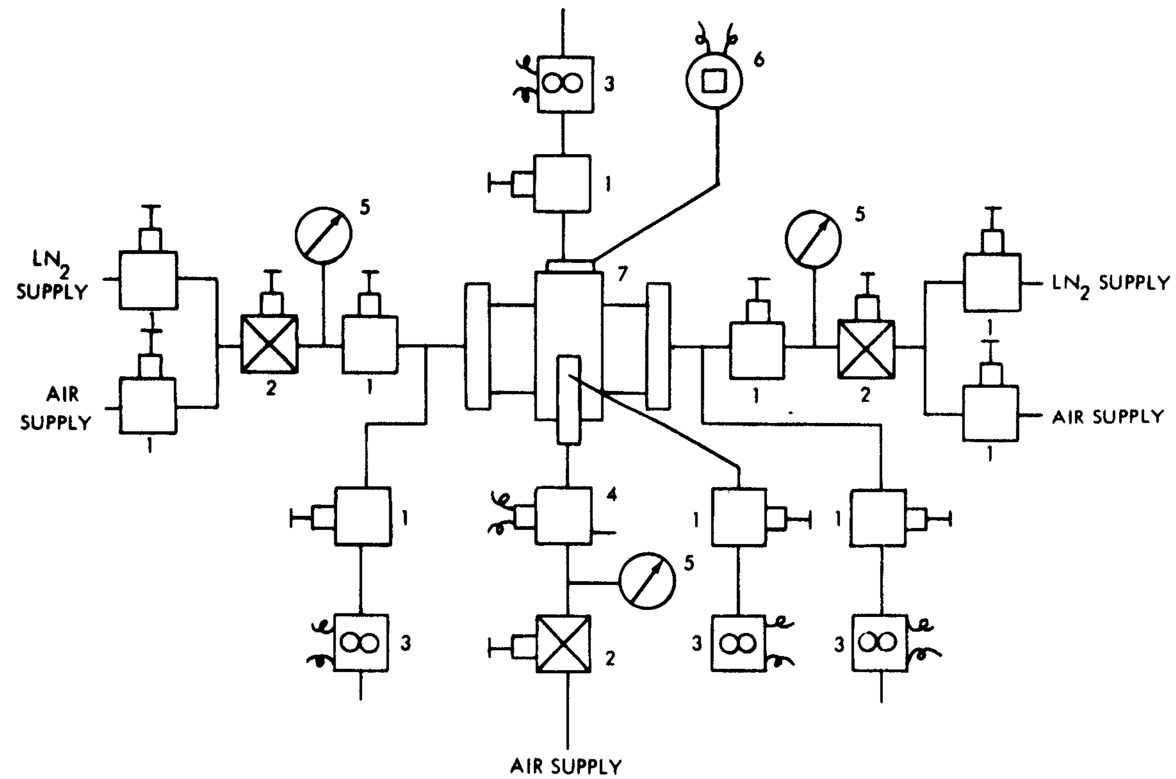
Figure 1. Proof-Pressure and Burst Tests Schematic



E14372

Figure 2. Schedule of Tests

60

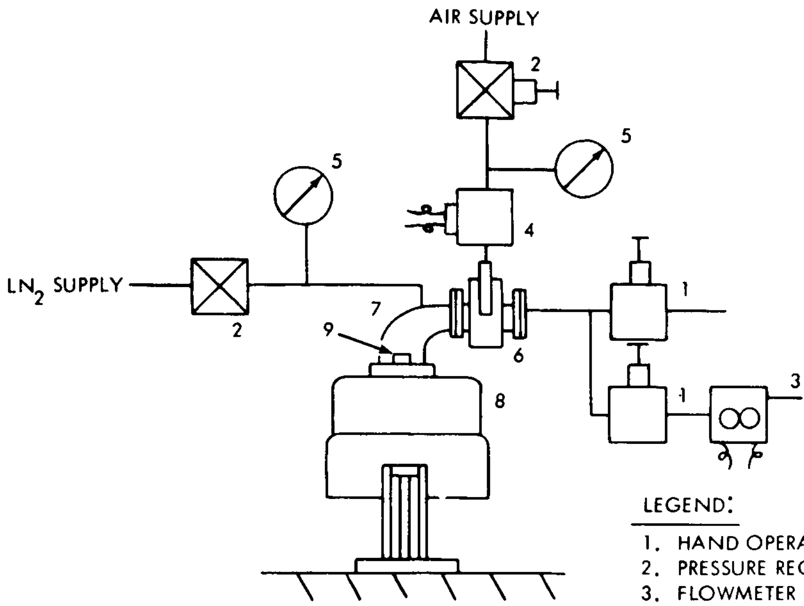


LEGEND:

1. HAND OPERATED VALVE
2. PRESSURE REGULATOR
3. FLOWMETER
4. SOLENOID VALVE
5. PRESSURE GAGE, 0 TO 1000 PSIG
6. TIMER
7. LOX REPLENISHING VALVE (60C20457)

Figure 3. Functional Test Schematic

E7789



LEGEND:

1. HAND OPERATED VALVE
2. PRESSURE REGULATOR
3. FLOWMETER
4. SOLENOID VALVE
5. PRESSURE GAGE, 0 TO 1000 PSIG
6. LOX REPLENISHING VALVE (60C20457)
7. ELBOW (20C00830)
8. VIBRATOR C-210
9. CONTROL ACCELEROMETER

E7791

Figure 4. Vibration Test Schematic

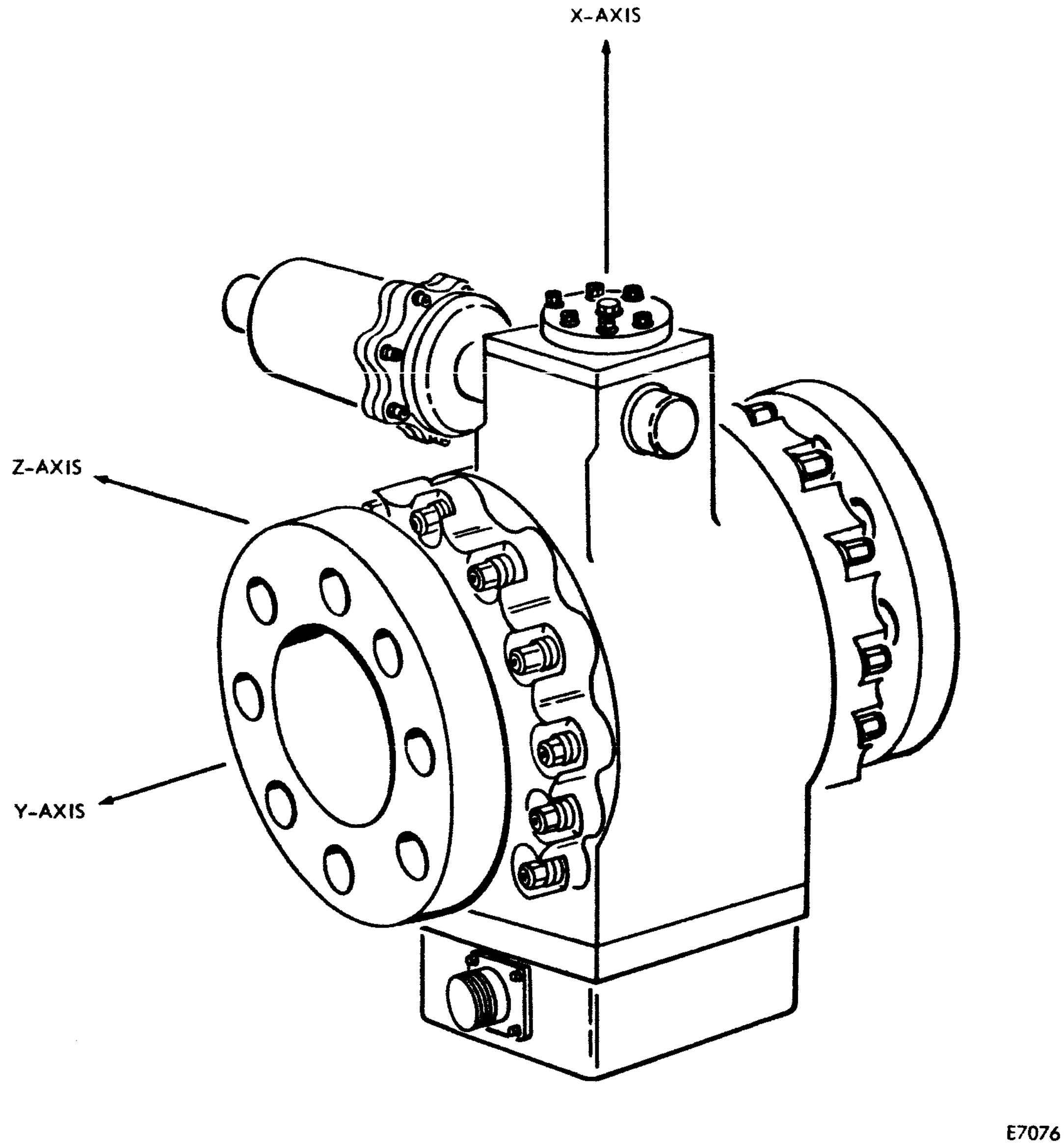


Figure 5. Major Axes of LOX Replenishing Valve

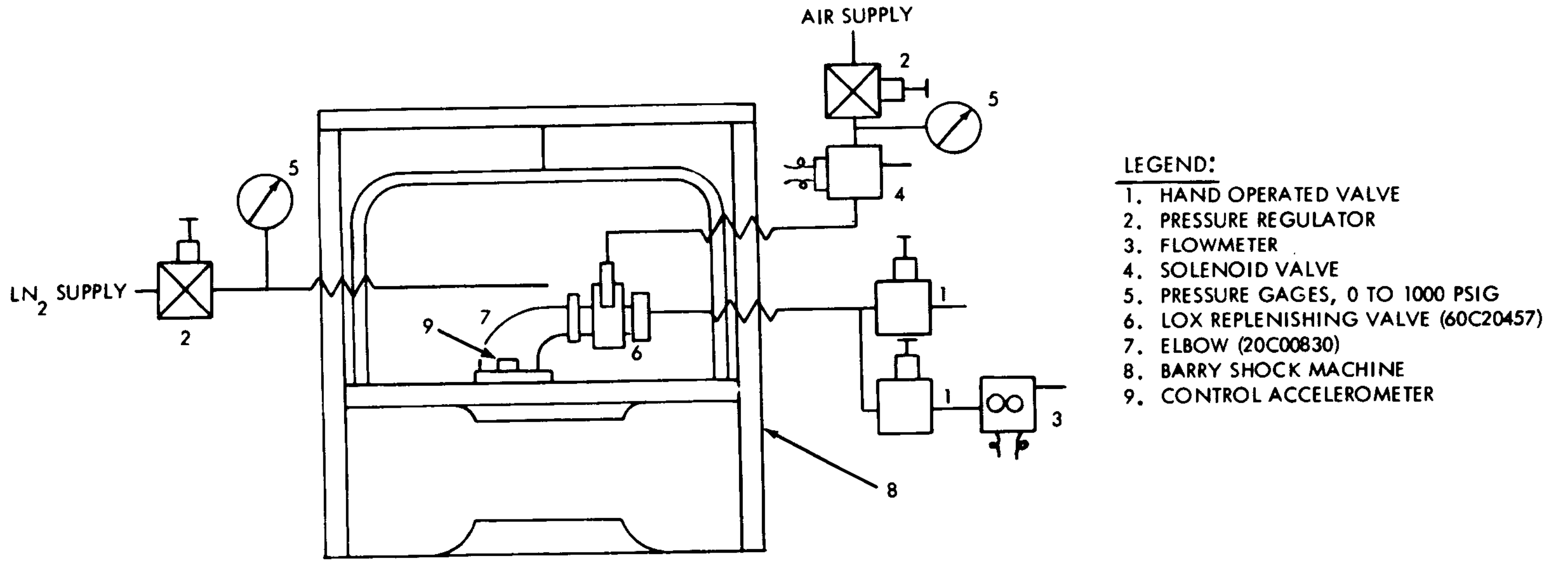


Figure 6. Shock Test Schematic

APPENDIX E

Reference Correspondence

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

H. Multhaup/G. Johnston/539-0284

TO Mr. Fuhrmann, Chief, Propulsion Engineering Branch, R-P&VE-PM

DATE March 25, 1964
R-P&VE-SVE-64-68

FROM Chief, Vibration and Acoustics Branch, R-P&VE-SV

SUBJECT Vibration Test of the LOX Replenishing Valve on the S-I and S-IB Stages

REFERENCE (a) IN-P&VE-S-62-7 Vibration, Acoustic and Shock Specifications for Components on Saturn I (Block II) Vehicle
(b) IN-P&VE-S-63-1 Preliminary Vibration, Acoustic and Shock Specifications for Components on Saturn IB Vehicle

The physical support of the LOX replenishing valve P/N 60C20457 (formerly P/N 20M30045), and elbow P/N 20M00830 is the sump of a 70 inch LOX tank. In view of this, it is recommended that these two components be tested to the specification in Sub-Zone 3-2-B of the referenced documents instead of Sub-Zone 2-1-A. It is also noted that the referenced documents erroneously state the part number for the elbow as 20M00820.

J. H. Farrow
J. H. Farrow

APPROVED:

[signature]
Chief, Structures Division

Copies to:
Mr. Schnelle, R-P&VE-PMC
Mr. Wargo, R-P&VE-PMC
Mr. Rothe, R-P&VE-VP
Mr. Haire, R-P&VE-VB
Mr. Hawkins, I-MICH-OA
Mr. Stevenson, I-MICH-PA
Mr. Corte, CCSD/M
Mr. Fillmore, CCSD/M

MSFC - Form 488 (August 1960)

INTER COMPANY CORRESPONDENCE

		FILE CODE	DATE 15 February 1965
TO - NAME D. Gorte	DEPT. 2732	DIVISION Space	PLANT/OFFICE Michoud
- NAME G. Rounis	DEPT. 2513	DIVISION Space	PLANT/OFFICE Michoud

SUBJECT: LOX REPLENISHING VALVE, P/N 60C20457

Of the six (6) subject valves which have been received and tested by CCSD, none have been accepted upon initial receipt. Of the two (2) which are now within the System, one was reworked twice before acceptance and the other received a "use as is" for service on S-1B-D/F. The remaining four (4) valves have been returned to the vendor (Parker) for rework.

RECEIVED FEB 19 1965 P. PERANI RELIABILITY TEST & EVALUATION SECTION # 2723

The attached defect summary clearly illustrates the areas of difficulty as well as the need of definite corrective action. The vendor liaison group has already been alerted and is presently evaluating vendor facilities, workmanship, and procedures. Qualification testing by the Reliability Testing and Evaluation section also has begun on two (2) of these valves and should be completed by March.

To supplement these activities, it is requested that a thorough design review be initiated. A re-evaluation based upon knowledge acquired from various and repeated failures of this component may prove of great value and assistance.

A concerted effort by each of the above-mentioned groups, along with a good working relationship among all three (3), is apparently what is required to eliminate many of the problems presently being encountered.

Finally, as a further means of quality assurance and control, this component has been added to the Receiving Inspection List of items which require initiation of the Functional Failure Analysis Data Sheet as per V.A.8. of SD-73.

G. T. Rounis

G. T. Rounis, Manager
Quality Assurance & Reliability

GTR/TB/mgw

cc: F. Brune
J. Koch
P. Perani
F. Kunze
R. Hughes
C. Glenn
R. Ponti
T. Mell
File

110-7879 REV. 1-63

DEFECT SUMMARY
P/N 60C20457
PARKER VALVE

SERIAL No.	IMR No.	Acc.	Rej.	DISCREPANIES	DISPOSITION
104	A39180 (10-5-64)		X	1) At LN_2 temp., 750 PSIG required to open valve — 500 PSIG max. is tolerance. 2) Closed indication at 1° which is 2° below the 5±2° tolerance. 3) At LN_2 temp., switch stuck in the closed position.	Returned to vendor
	A34801 (12-7-64)		X	Shaft seal leakage of 70 SCIM — 60 scim above 10 scim max tolerance.	Reworked In-house
	A39028 (12-7-64)	X			
105	A39180 (10-5-64)		X	1) At LN_2 temp., 750 PSIG required to open valve — 500 PSIG max. is tolerance. 2) At LN_2 temp., switch stuck in the closed position.	Returned to vendor
	A34801 (12-7-64)		X	Shaft seal leakage of 76 SCIM — 66 scim above 10 scim max. tolerance.	Returned to vendor
103	A23346 (11-20-64)		X	At LN_2 temp., valve would not fully close.	Accepted for use on S-IB-D/F
106	A33226 (12-23-64)		X	Control piston leakage when 750 PSIG applied to control port.	Returned to vendor
108	A33226 (12-23-64)		X	1) Control piston leakage when 750 PSIG applied to control port. 2) Closed indication at 1° which is 2° below the 5±2° tolerance.	Returned to vendor
107*	A51718 (1-5-65)		X	1) Closed indication at 2° which is 1° below the 5±2° tolerance. 2) At LN_2 temp., valve would not fully close. 3) Shaft seal leakage of 90 scim - 80 scim above 10 scim max. tolerance.	Returned to vendor
				*Listed as P/N 60C27896 since it is intended for use on S-IB-D/F.	

DEFECT SUMMARY

– PAGE 2 –

DEFECT CATERGORIES

RECEIVED*	REJECTED
9	8

THERE WAS A TOTAL OF 14 VARIOUS DEFECTS WHICH ARE LISTED BELOW:

1. Closed indication BELOW the $5 \pm 2°$ tolerance 3
2. At LN_2 temp., over 500 PSIG required to open valve 2
3. At LN_2 temp., switch stuck in open position 2
4. At LN_2 temp., valve not fully closing 2
5. Shaft seal leakage (in excess of 10 scim) 3
6. Control piston leakage 2

14

*Each separate inspection by Receiving is considered as a reception.